

# ILLUMINATING ENGINEER

XXV

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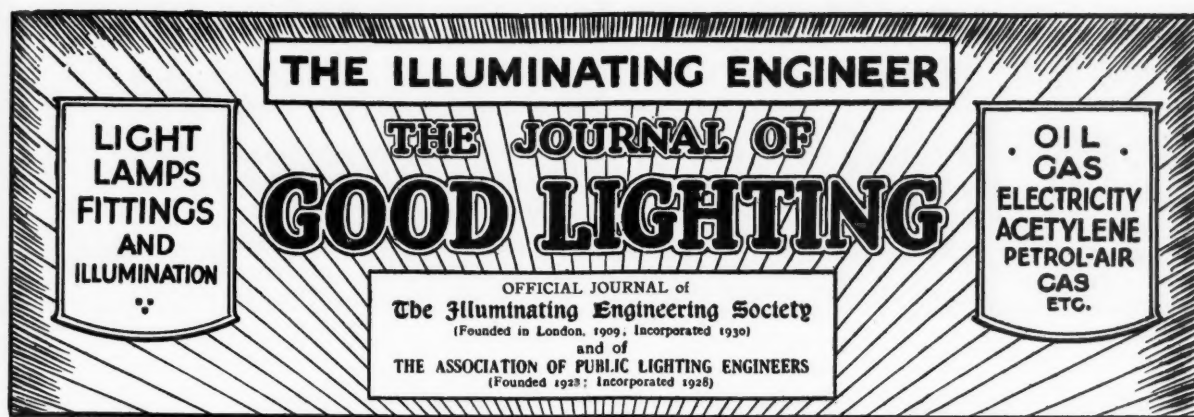
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J. STEWART DOW

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## Progress in Illuminating Engineering

THE Opening Meeting of the Illuminating Engineering Society, on October 11th, was noteworthy for a reversion to the original practice of the Society—the Presidential Address being delivered on this occasion instead of at the end of the Session. The former is the more usual practice, which we hope will be followed by future presidents. The installation of Lieut.-Commander Haydn T. Harrison in the chair was a pleasant reminder of his long services to illumination. His address revived early memories—for example, of the inaugural dinner in 1909, when the formation of the Illuminating Engineering Society was agreed upon. The address also dealt in a large measure with street lighting, a field with which the author has long been specially identified.

The Report of Progress, as usual, contained a record of steady progress, which was again illustrated in the exhibits which followed. Whilst there were perhaps no very outstanding advances during the past year, there have been at least two developments which certainly constitute "milestones"—the development of the new highly efficient luminous gas-discharge lamps, and the introduction of portable physical photometers in which the response of photo-electric cells replaces a comparison of brightness by the human eye. More will be heard of the gas-discharge lamps at the next meeting of the Illuminating Engineering Society on November 8th, when Mr. C. C. Paterson is to give an address on this topic. Amongst the exhibits on October 11th were two distinct forms of photo-electric photometer, different somewhat in aim and method, but both extremely interesting.

If the other exhibits chiefly illustrated progress in detail, they were none the less informative. The display of electric incandescent lamps revealed several new developments—for instance, in photographic lamps and series lamps for use on tramways. The lamps and fittings shown also revealed new possibilities for decorative lighting, curved tubular lamps executed in diffusing material being one novel device. Perhaps one of the most entertaining of all the exhibits was the new "action" sign described by Mr. Beuttell and illustrated by means of a film. This will doubtless be seen in operation in London before very long. Finally, the new demonstration equipment at the E.L.M.A. Lighting Service Bureau, described elsewhere in this issue, was in itself a most attractive exhibit.

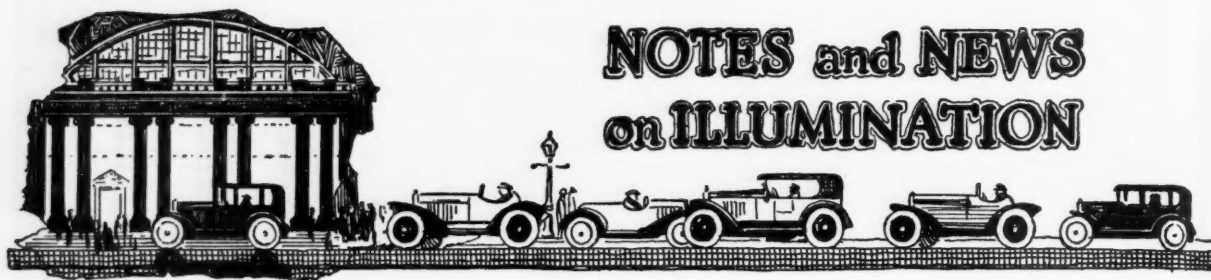
## The Lighting of Picture Galleries

THE lighting of picture galleries, in most cases buildings of some antiquity, is rarely well done. Methods desirable in theory are often difficult to apply in practice, but it may be doubted whether, even in theory, the problem has yet been satisfactorily solved. In a paper read before the Royal Society of Arts on October 3rd, Mr. Robert Howden dealt cogently with certain difficulties. He remarks how singular it is that authorities throughout the world have no clear understanding as to the nature and intensity of light that causes fading. He argues, with some force, that a scientifically designed system of artificial daylight, substantially free from the destroying rays, is preferable to capricious and variable sunlight.

The main topic of the paper, however, is the elimination of reflections from the glazed surfaces of pictures. Glazing must be accepted as a necessary precaution against spoilage, malicious or accidental, of valuable paintings. In addition, the enclosure of priceless masterpieces in an atmosphere of inert gases, which helps to delay the process of fading in itself, makes the use of glass necessary.

Next it must be admitted that reflections of bright objects in the glazed surfaces of pictures do constitute a real nuisance, and it is questionable whether any mode of lighting, however scientific, can eliminate them entirely. The most effective suggestion, that pictures should be brightly lighted whilst the audience view them from complete shadow is good in principle, but unpopular with the public; moreover, there remains the difficulty that images of illuminated pictures on the other side of the room would still be seen—unless the pictures are mounted only on one side of the room, the other wall being left blank and finished in dark material.

Mr. Howden's solution is based on the application to pictures of an idea already developed by Mr. Gerald Brown to overcome the same difficulty in the case of shop windows. The essential idea is the curving of the glass so that only reflections from certain sections of the room—which are treated with very dark material, so as to render these reflections practically invisible—are produced. Very large pictures might require individual treatment, but in general a number of pictures of average size might be confined within the same enclosure (which incidentally might be gas-tight, and thus serve to contain the desirable atmosphere of inert gases), and the same glass front would serve for all.



## NOTES and NEWS on ILLUMINATION

### How Much Does Good Street Lighting Cost?

Professor F. C. Caldwell has favoured us with a copy of a report with the above title, presented at the recent Convention of the American Illuminating Engineering Society (U.S.A.). This contains some striking statements in regard to the influence of public lighting on safety. Comparisons of conditions in streets before and after better lighting was introduced are said to indicate a reduction of 60 per cent. in accidents occurring after dark. Information of this character is, however, scanty. More extensive data comparing the number of accidents during the early evening hours, which are dark in winter but light in summer, have been obtained. Three studies, covering 90 cities and 34,406 accidents, have been made on this basis. From these data the inference is drawn that *half* the night accidents in cities could be eliminated if artificial illumination as effective as (not necessarily equal to) daylight were furnished. Another interesting statement based on surveys in twelve different districts, is that not less than 45 per cent. of traffic accidents occur at night, the percentage in the case of fatal accidents being materially greater. These and other data form the basis of a calculation that if the present cost of street lighting in the U.S.A., about 1.20 dollars *per capita*, were increased to 2.50 dollars *per capita*, so as to give reasonably good illumination, the net profit to city dwellers would be about 68 per cent. A fundamental difficulty, underlying all such calculations, is that an individual person who pays increased rates for street lighting does not necessarily obtain this 68 per cent. return as a personal profit, and it is not always easy to induce people to take broad views. Apart from this consideration, the statistical data in this report are exceedingly interesting. If the committee of the National Safety-First Association now studying street accidents could establish similar relationships for this country we should have at our command a very powerful argument in favour of better public lighting.

### Luminous Signals for Motor-cars

We hear that luminous signal devices, indicating when a driver proposes to turn to the right or left, to slacken speed, or stop, etc., are likely to prove an important feature in new models of motor-cars, and that the Ministry of Transport is considering the framing of rules applying to such devices. This development is long overdue. In the future it will surely seem strange that motorists were so long content to attempt imperfect signalling by hand—as strange as the want of imagination that for so long condemned officers on point duty to fatiguing semaphore motions with their arms instead of operating easily controlled light-signals. One is also glad to note that the illumination of traffic and direction signs of all kinds is receiving more attention from the authorities in connection with the regulations for standardization that are now being framed.

### Courses in Illuminating Engineering

One not infrequently hears enquiries for instruction in illuminating engineering, coupled with an expression of surprise that so little is done in this direction at technical colleges. Admittedly our arrangements in this country are less complete than in some others. But in fact there are better facilities available than is generally recognized, the chief difficulty being that courses, where they exist, are not sufficiently widely known. An instance is afforded by the Northampton Polytechnic Institute (where incidentally the very first course of lectures on illuminating engineering in this country was organized by the Illuminating Engineering Society in 1912). The syllabus of the course, now before us, seems quite a comprehensive one. Like other special courses at the Northampton Institute, it involves attendance on three evenings a week, lectures being supplemented by practical work. The complete course extends over two years. We feel sure that its existence only needs to be known to ensure a good attendance, and we advise all those who are interested to get in touch with Mr. A. C. Jolley, at the Northampton Polytechnic Institute (St. John Street, London, E.C.1), from whom further particulars may be obtained.

### Subway Lighting in Paris

A description in the *Electrical Review* of the lighting of a new subway in Paris furnishes a striking instance of the new outlook on installations of this kind. In the past the lighting of subways has been notoriously unimaginative—the advantage of allowing a free view down the tunnel being sometimes quite overlooked. The Parisian subway is equipped with lanterns set flush with the walls of the tunnel, so that there is an unobstructed view and commendable limitation of glare. What, however, is specially noteworthy is the automatic control of the intensity of the lighting. In recent subway installations the desirability of accentuating the illumination at the ends, so that the contrast with daylight illumination should be as little as possible, has sometimes been recognized. In this case, however, the recognition of the influence of daylight goes further. Four levels of illumination corresponding to full sunlight (135 lux), ordinary weather (60 lux), dull weather (32 lux), and night (15 lux), being furnished, the desired intensity being turned on through the agency of a selenium cell mounted within a diffusing globe at the top of a lamp-post in the open-air. The change in illumination is effected by varying the number of lamps. Another feature is the use of automatic contact-makers permitting a duplicate electric supply to come into action in the event of the ordinary one failing, and thus ensuring no interruption of the lighting of the subway, which is 820 ft. in length. It might perhaps be argued that the daylight outside could scarcely influence the effect on the eye of the lighting at the centre of such a long subway; but it is probably more convenient to make changes in illumination apply to its entire length.

## TECHNICAL SECTION

COMPRISING

### Transactions of The Illuminating Engineering Society and Special Articles

*The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.*

## Progress in Illuminating Engineering

(Proceedings at the Opening Meeting of the Illuminating Engineering Society, held at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, Strand, London, W.C., at 6-30 p.m., on Tuesday, October 11th, 1932.)

THE opening meeting of the Illuminating Engineering Society took place at the E.L.M.A. Lighting Service Bureau (2, Savoy Hill, Strand, London, W.C.), at 6-30 p.m., on Tuesday, October 11th, when Lieut.-Commander Haydn T. Harrison, M.I.E.E., R.N.V.R. (President), took the chair.

After the minutes of the last meeting had been taken as read, the HON. SECRETARY announced the names of new applicants for membership, which were as follows:—

#### Corporate Members—

- Bright, H. .... Consulting Engineer, Premier House, 150, Southampton Row, London, W.C.1.
- Downer, G. V. .... G.V.D. Illuminators, Aldwych House, London, W.C.2.
- Fielden, S. .... Representative of Lighting Trades Ltd., 137, Burnage Lane, Didsbury, Manchester.
- Gloag, J. .... Author and Journalist, 3, The Mall, East Sheen, London, S.W.14.
- Harper, Lieut. Duncan H., R.N., "Medford," Bentham Road, Alverstoke, Hants.
- Holmes, R. R. .... Lighting Consultant, 19, Pembridge Gardens, London, W.2.
- Hunt, W. R. .... Branch Manager of Messrs. Falk, Stadelmann & Co. Ltd., 102, Frederick Road, Stechford, Birmingham.
- Lamotte, G. W. L. .... Lighting Expert, 99, Cadogan Gardens, London, S.W.3.
- Orchard, C. H. .... Lighting Department, Messrs. Falk, Stadelmann & Co. Ltd., 83-93, Farringdon Road, London, E.C.1.
- Pride, H. C. .... Manufacturer of Lighting Fittings, 52, Great Marlborough Street, London, W.
- Quinn, W. L. .... Technical Lighting Assistant, Messrs. Falk, Stadelmann & Co. Ltd., 246, Clyde Street, Glasgow.
- Roberts, A. B. .... Industrial Gas Representative, The Gas Light & Coke Company, Horseferry Road, London, S.W.1.
- Champion, C. H. .... Electrical Engineer, 60-66, Wardour Street, London, W.1.

#### Country Member—

- Hodson, N. C. .... District Representative, Verity's Ltd., 36, Melville Road, Stretford, Manchester.

The names of applicants presented at the last meeting\* were read again, and these gentlemen were formally declared members of the Society.

The Hon. Secretary then mentioned a new arrangement which the Council desired to introduce,

namely, that after the reading of the membership lists a period of five minutes should be available at each general meeting, during which he would bring before the notice of members any special points of interest to them, such as the work of committees or announcements from the Council. For the moment, he only wished to recall the new leaflet and list of members which Mr. Young and the Membership Committee had prepared, and which had been circulated to all members. He hoped that they would back up these efforts by trying to interest others in the work of the Society, and thus gain new members.

#### AWARD OF LEON GASTER MEMORIAL PREMIUM.

The CHAIRMAN then announced that the Council had unanimously decided to award the Leon Gaster Memorial Premium for the past session to Mr. E. S. Calvert for his paper on "Motor-car Headlights," read before the Society on January 8th.

The premium, accompanied by a certificate on vellum recording the award, was then presented to Mr. Calvert amidst general applause.

#### REPORT ON PROGRESS.

The HON. SECRETARY then briefly presented the Report on Progress (see pp. 281-285), which, as usual, had been prepared by the Technical Committee, and was now available in printed form. He remarked that this was again a record of steady progress, without there being any very outstanding achievements to record, and mentioned a few minor corrections which would be made in the final version to appear in the Journal.

#### THE PRESIDENTIAL ADDRESS.

Lt.-Commander HAYDN T. HARRISON, M.I.E.E., R.N.V.R., then delivered the Presidential Address, which will be found *in extenso* on pp. 277-280. This address, which consisted in part of a historical survey of developments in illumination, and in part of a discussion of various outstanding problems in connection with public lighting, was heard with great interest. This is the first occasion for a number of years on which the Presidential Address has been delivered at the opening of the session; future Presidents will no doubt follow the excellent course which has now been initiated.

#### EXHIBITS.

The exhibits illustrating progress in illumination were exceptionally numerous, fourteen separate

\* *Illum. Eng.*, July, 1932, p. 178.

items being included in the programme. After Mr. W. J. Jones had briefly referred to the new and effective demonstrations devised at the Bureau, which were closely examined afterwards by members, novel and interesting forms of incandescent lamps were shown by Mr. K. V. Mackenzie, Mr. S. J. Patmore and Mr. F. G. Thomson. A film illustrating a new and highly interesting form of animated electric sign was then shown by Mr. A. W. Beuttell, after which Mr. J. G. Holmes and Mr. J. M. Waldram in turn showed devices for tracing the path of light-rays through prisms in refracting glassware.

Another group of exhibits had to do with photometry. Mr. S. A. Williams showed a new and remarkably simple form of "physical" photometer based on the use of a photo-electric cell, and a more elaborate equipment of this type was demonstrated by Mr. G. T. Winch. Mr. F. Ockenden showed an improved form of the "luxometer," and an improved type of Waldram Daylight Gauge was also on view.

Novel types of fittings were shown by Mr. T. Barnicott, Mr. A. Murray Coombs, Mr. T. E. Lane, Mr. E. J. Stockwell and Mr. E. Stroud.

Votes of thanks to the Chairman for his address, to the exhibitors for their interesting display, and to the E.L.M.A. Lighting Service Bureau for their hospitality terminated an enjoyable evening.

A full and illustrated account of these exhibits will appear in our next issue.

## Visit to the Shakespeare Memorial Theatre, Stratford-on-Avon

Nearly 60 members of the Illuminating Engineering Society and friends, who visited the Shakespeare Memorial Theatre, on October 18th, had a very pleasant and informative experience. The party leaving London numbered nearly 40. On arrival at Coventry, shortly after 1 p.m., they were taken by motor-coach to Warwick, where lunch was taken and some of the party were able to pay a hasty visit to the famous and delightfully situated castle. On arriving subsequently at the theatre at Stratford-on-Avon at 3-30 they were joined by a contingent from Leicester, Birmingham and other centres.

The visitors were conducted over the theatre by Mr. Chesterton, a member of the firm of architects (Messrs. Scott, Chesterton and Shepherd), and then occupied the stalls whilst an address describing the lighting, carried out under the supervision of Messrs. Ridge and Aldred, was delivered by Mr. C. Harold Ridge. After inspection of the stage, tea was provided, in the course of which Dr. J. W. T. Walsh expressed a cordial vote of thanks to Mr. Tossell, the manager of the theatre, to Mr. Chesterton and Mr. Ridge, and to Mr. Rendell Baker, who had gone to much trouble in arranging for the demonstration of the lighting.

(An illustrated description of the lighting of the theatre will appear in our next issue.)

## Light and Insight ; Illumination and Vision

**I**N the opening remarks of his Ettles lecture, delivered before the Institute of Ophthalmic Opticians, on October 6th, Sir Francis Goodenough explained that the above title was derived from a phrase adopted by Mr. C. C. Paterson in an address some years ago ("Light had they, but no insight; illumination, but no vision"). Technicians were somewhat apt to devote themselves to the perfecting of their tools rather than the objects they served. For many years the chief task had been that of producing light more economically and abundantly. But the Illuminating Engineering Society, whose presidential chair he had occupied during the past year, were concerned both with the means of producing light and its effects, furnishing a meeting place alike for the producer and the user of light.

The founder of that Society, the late Mr. Leon Gaster, had been impressed by the importance of the knowledge of the ophthalmist to the illuminating engineer. This help was still needed. For it is on the impression of the eye that one's judgment of the quality of a lighting installation ultimately depends.

Sir Francis then proceeded to recall the services rendered by several eminent ophthalmic surgeons and opticians as members of the Illuminating Engineering Society. The very first paper read before the Society, in 1909, was that by Mr. (now Sir) John Herbert Parsons on "Glare—its Causes and Effects." Dr. W. Ettles (in whose memory this lecture is instituted) took part in the discussion of that paper. He had been closely associated with him (Sir Francis) on at least two occasions—as lecturers in the course on illuminating engineering arranged at the Northampton Institute in 1912, and as members of the Joint Committee on School Lighting which reported in 1913.

In the next section of his address Sir Francis attempted to frame a definition of good lighting, emphasizing the primary requirements of sufficient illumination, absence of glare, elimination of trouble-

some shadows, and constancy of the light. As yet there was no absolute legal standard, and one could only arrive at a definition through the study of the eye. These requirements were considered in turn by the lecturer. He referred to the now familiar and important enquiry of the Illumination Research Committee into the influence of illumination on type-setting by hand. There was a general and doubtless justified belief that constant work in inadequate light must have a prejudicial effect on vision. Nevertheless there was, on the physiological side, little positive evidence of such injury.

Similarly, notwithstanding all that had been written on the subject of glare during the last twenty years, there was still no simple test one could apply to ascertain whether or no an installation was unduly "glaring." In these directions the aid of the ophthalmologist was needed. Sir Francis also touched upon the intimate relation between eyesight and a demand for strong illumination, which must meet the needs of the worker with the lowest level of vision. The need for eyeglasses or spectacles should not be overlooked. If a worker's eyes needed correction so that he could not obtain a clear image of the material, no amount of illumination would put this right! In the case of some forms of very close work, such as "inking" hosiery, Mr. H. C. Weston had shown the need for magnifying-glasses even by those with relatively good eyesight.

The concluding sections of the address were concerned with the influence of higher illumination on the resolving power of the eye, the effect of the nature of the material illuminated, and the influence of contrast and colour in the light-source—all problems with which the optician is intimately concerned. In conclusion, Sir Francis expressed the hope that he had been successful in leading the ophthalmic surgeon and the optician to realize how highly their assistance is desired and valued by the illuminating engineer.

## Presidential Address

By Lt.-Commander HAYDN T. HARRISON, M.I.E.E., R.N.V.R.

(Address delivered at the Opening Meeting of the Illuminating Engineering Society, held at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, Strand, London, W.C.2, at 6-30 p.m., on Tuesday, October 11th, 1932.)

**B**EFORE proceeding, I wish to thank the members of the Society for electing me as their President, a position the honour of which I greatly appreciate.

At the first meeting of this Society in 1909 the late Silvanus P. Thompson, our first President, delivered an Inaugural Address in which he stated that "this Society has been formed to bring together all those who are interested in the problems, practical and theoretical, of the *art of directing and adapting light*, that prime necessity of civilized as well as of uncivilized existence, *to the use and convenience of man*." A better definition of our object would be difficult to find, and I would have preferred to give up the whole of this address to describing the technical details of our progress in this direction, but so much has been done that the time at my disposal will only allow of a general survey.

Our last President, Sir Francis Goodenough, in his Presidential Address, which he delivered a short time back, dealt with the general work of the Society since its inception; this leaves me free to deal more especially with the branch to which I have devoted so much of my time, namely, street lighting or public lighting generally.

Professor Thompson, in the address referred to, states that "for practically a century only have there been any systematic means of illumination," and that only in the larger towns and cities was there any organized attempt to light the streets by oil lamps, but history informs us that in the year 1745 Matherot de Prugney and Bourgeois de Chateaublanc developed new street lanterns embodying oil lamps and polished metal reflectors called "reverbère," and in 1763 the French Academi des Sciences awarded to Chateaublanc a prize for "the best way of lighting a large city, ensuring as far as possible safety, economy and duration." Chateaublanc claimed that the light from his "reverbère" was so intense that a person could be recognized 30 paces away." It is further interesting to note that even at that time "numbers of people found the light too brilliant, and complained that it tired the eyes of passers-by and blinded coachmen and horses," to which Chateaublanc replied that "it was because they gazed at them (the lights) with too much admiration." He further maintained "that it was not necessary to look at his lanterns (which were suspended 25 to 35 ft. high), and that they should concentrate their attention on their feet and surroundings; as regards the coachmen, they should be looking at their horses, while the horses themselves could not easily walk with their heads in the air." Which, to the mind of the speaker, is a very practical answer.

The road from Paris to Versailles was lighted by means of these "reverbère" for over 16 years. History states that there were nearly 6,000 of these lanterns in Paris alone and that they remained there until replaced by gas lamps.

It is interesting to note that this must have been the first street-lighting specification, and that it demanded "a reflector of copper, silver-plated."

All this happened nearly two hundred years back. Those who went to the exhibition held in conjunction with the Annual Conference of the Association of Public Lighting Engineers at Blackpool this year found themselves surrounded by lanterns with polished reflectors which might have been silvered

copper, but which in fact were chromium, stainless steel or silvered glass intended for gas or electric light. Nevertheless, the object of these adaptors was the same as that of Matherot de Prugney and Bourgeois de Chateaublanc.

Thus does history repeat itself, not only as regards the use of specular reflectors in street lighting, but also in raising objections to what we now call glare, but are still unable to define or prevent.

It is not proposed to discuss glare in this address, as the author's views are very similar to those of Bourgeois de Chateaublanc. The lamps were even then placed in a position which made it possible to avoid their rays. The fact that horses have been replaced by motor vehicles, the headlights of which produce more glare than any artificial light contemplated at that time makes it the obvious duty of illuminating engineers dealing with street and road lighting to render it possible to dispense with such headlights.

The information that faces could be recognized at 30 paces brings us to the subject of illumination which is now the basis of street-lighting specifications, and the question naturally arises under which class of the British Standard Specification on Street Lighting could this ancient example of street lighting be placed. We can imagine "Notes on testing," in Appendix I of our present specification revised to suit this very practical test adopted by Chateaublanc; it would not require to be modified to any great extent. Horizontal illumination near the ground at a test-point would become vertical illumination at five feet above the ground at a prescribed distance from the source. Various classes would be distinguished by varying distances at which the vertical illumination was necessary to recognize faces. This, as a proposal, is of a very practical nature, and would no doubt be strongly supported both by the police and the public, who do not take much interest in horizontal road surface illumination. On the other hand, there are those who consider it advisable to cut the light off the faces in order to avoid glare who would look askance at such a proposal. I dealt with this matter in my paper read before the Institution of Electrical Engineers in 1905. All the pros and cons have since been carefully considered many times, and horizontal illumination has eventually been chosen by the British Standard Specification Committee. But not a minimum horizontal illumination three feet above the ground, as recommended by Mr. Trotter's committee, but horizontal illumination at a prescribed test-point, this has been found to introduce certain difficulties which cannot be discussed in this address. There is still a very large proportion of roads in this country in which faces could not be recognized at 30 paces from the light-sources, which are rarely arranged as close as 90 ft., and it must be remembered that a face is not necessarily illuminated by the adjacent lamp but by the one to which it is turned.

The author does not depreciate the British Standard Street-lighting Specification; being one of the members of the committee responsible for its production, he feels proud of the issue of the only practical specification which exists, and would like to take this opportunity of giving honour where honour is due, namely, to our past President, Mr. C. C. Paterson, whose chairmanship of the committee has led to the achievement of an object which had so far not been attained.

I will now pass over a period of nearly 150 years, during which the only important advance in street lighting was in the nature of light-sources, and not in their application. Oil lamps were superseded by luminous-flame gas burners, which in their turn were replaced by upright gas mantles, inverted mantles and high-pressure gas. In the case of electricity Jablecoff electric candles, open type, enclosed type, and flame arc-lamps had their day among the high-power units, during which period carbon incandescent lamps, tantalum, osmium and tungsten-filament vacuum lamps, gave way to gasfilled incandescent lamps. To-day we are contemplating the disappearance of the filament in place of arc discharges through inert gases contained in glass envelopes, the size and shape of which may greatly affect in future the work of the illuminating engineer.

All this has meant the cheapening and greater reliability of artificial light-sources, until we have nearly reached the point when the cost of the actual light energy is often less than the cost of maintenance and interest on the cost of installation. Such a state of affairs must necessarily put more responsibility on the shoulders of the architect, the illuminating engineer and the installation contractor. Take, for example, daylight, for which we pay nothing; it depends on the architect how much of this commodity we get inside our houses, public buildings, etc. He relies to a large extent on illuminating engineers, just as he does on structural steel engineers, etc., for his building construction. It must be admitted that in the past daylight has not always been dealt with satisfactorily—probably because it cost nothing; this serious error must not be repeated with artificial lighting, even if the cost of the luminous energy is a small fraction of the total. Let us rather simulate nature by giving a bountiful supply of luminous energy when artificial lighting is required for anything except restful purposes.

In 1890 we find photometry and actual measurements of luminous intensity being used more as a gauge of the quality of gas flame than for any other purpose. Gas engineers of those days thought more of 14, 15 or 16-candle gas, and W. H. Y. Webber, in his interesting book published in 1892, mentions that "Edinburgh rejoiced in 27-candle gas," and goes on to say "that while the literature of gas engineering is full of references to a most exact and refined photometry, it is almost a blank space on the subject of illumination as we understand it to-day." Nevertheless, Webber boldly attacks the subject of illumination, both exterior and interior, and introduces a "Table of Lighting," based on the work of a Mr. Richards, published in the *Electrical Review* of that time, the results having been determined experimentally by the aid of a standard candle. Extracts from this table are given below; the column marked D has been added, and is reduced to foot-candles in order that the recommendations of nearly 50 years ago may be compared with those generally circulated at the present time.

TABLE OF LIGHTING.

A	B	C	D
Style.	Lighting suitable for	1 candle at feet Intensity = of distance	Illumination resulting in Foot-candles.
No. 1	Road or pavement	10 ft.	0.01 f.c.
No. 2	Walls	8 ft.	0.015 f.c.
<i>Church Lighting—</i>			
No. 3	General light	4 ft.	0.06 f.c.
No. 4	Pew or reading desk	0.5 to 0.3 ft.	4 to 11 f.c.
<i>Workshop Lighting—</i>			
No. 7	General light	5 ft.	0.4 f.c.
No. 8	Benches	0.3 ft.	11 f.c.
No. 9	Office or fine work	0.2 ft.	25 f.c.
No. 13	Reading table	0.5 ft.	4 f.c.

When making comparisons it must be remembered that these primitive tests did not take any notice of the angle of incidence of the light, nevertheless it is remarkable that views of the necessary illumination should have altered so slightly in the last 40 to 50 years.

In those days the degree of illumination scheduled can rarely have existed in practice, which unfortunately still applies to-day.

The similarity which exists between the old schedules and those now in circulation may lead some to wonder if any material progress has been made; it is therefore of interest to mention that our Society has under consideration the revision, based on more modern methods of photometry, of the values of illumination at present recommended.

Before passing to another subject I would like to call the attention of my listeners to "Style 2" of the old table of lighting, namely "Walls" of streets. These rarely receive any consideration at the present time, though they should in practice be considered part of the area to be illuminated; in other words, streets bounded by buildings on either side are a different proposition to roads or highways bounded by open country or gardens in front of houses.

The duty of the public lighting authority is to illuminate the road and footways and all objects and obstructions thereon which need to be visible for the public safety and convenience, but the buildings bordering it cannot be considered as coming within this category. The decision as to the lighting of these is therefore in their hands. The B.S.I. Specification does not help them in this matter, but I would suggest that the degree to which it is intended to illuminate walls should be considered, and the surface area to be covered should be stated as part of that requiring illuminating energy.

As regards photometry, this may be of a practical or theoretical nature; my first experience of its practical use was in 1890, when assisting Dr. Fleming (now Sir Ambrose Fleming) with some research work for the late S. Z. de Ferranti, for which purpose I fitted adjacent to the testing department of which I was in charge, a photometric laboratory which was very different to that used by the gas engineers for testing the quality of their gas.

In 1892 Mr. A. P. Trotter, another of our past Presidents, read before the Institution of Civil Engineers his now historic paper entitled "The Distribution and Measurement of Illumination," which he prefixed with an introduction, every word of which is as true to-day as when it was written. I would like to have read to you the whole of this introduction, as it sums up in that clear and brief way typical of its author, much which is not even now understood by many illuminating engineers. He deals with what was then beginning to be known as the candle-foot, which, by his own later exertions, became the foot-candle of to-day. He stated "the candle-foot is a very convenient and comfortable illumination," and then proceeded to measure the illumination on the President's desk, which he found to be 0.8 candle-foot. In that paper are actual curves showing the contour lines of equal illumination in various streets round Westminster, many of these embodying more than two lights; these are now known as "isolux" or "iso foot-candle" curves. Mr. Frederick C. Smith, in his paper read before the Association of Public Lighting Engineers at Blackpool this year, presented similar curves of

the same district as lighted during September, 1931, on the occasion of the International Illumination Congress. There is a great difference, for when Mr. Trotter tested it, about 1890, the minimum horizontal illumination was 0.05 foot-candle, whereas during 1931 the minimum was 2.5 foot-candles. This must not be taken as indicating the general improvement in street lighting during the last 40 years, but as a proof of the soundness and practicability of Mr. Trotter's method of measuring and comparing the illumination of streets.

The principal object of Mr. Trotter's paper was, he states, "to attempt to enable engineers to pre-determine, specify for, and provide a definite illumination," that it was the precursor of all modern specifications there is no doubt, especially those relating to street lighting. As regards interiors, it led the way to such standards as illumination on the working plane, etc. Nevertheless, Mr. Trotter was very careful to point out that "illumination on the ground must not be the only consideration of outdoor lighting."

Shortly after that I commenced to make measurements in the streets, the results of which led me to read papers before the Institution of Electrical Engineers in 1905 and 1910, the latter of which led to the formation of the first committee in the country to consider "Standard clauses for inclusion in a specification of street lighting," which for nearly two years sat under the chairmanship of Mr. Trotter, and in 1913 resulted in a paper read by him before this Society. This will be found reported in full in Vol. 5, No. 4, of the *Illuminating Engineer*.

In the meanwhile the study and practice of illumination had proceeded rapidly, not only had the *Illuminating Engineer*, a journal we all know so well, been started by the late Mr. Gaster, in January, 1908, but also this Society had been formed at the interesting dinner held on February 9th, 1909, to which our last President referred in his address. At this dinner, the honour of proposing the toast of the Illuminating Engineering Society fell to me, and I was only too pleased to couple with it the name of Mr. J. S. Dow, our present Honorary Secretary, to whom so much of the success of this Society is due.

The contributors to the first copy of *The Illuminating Engineer* include some well-known names, for example that of Sir Ambrose Fleming, whose article was on vacuum-tube electric lighting. Little did we know at that time that his researches in this direction would lead to sound-transmission all over the world without the use of wires, or to broadcasting, which has now become a public and domestic necessity.

It also now appears probable that a modification of the electric lamp he described then may soon become practical for every purpose, and will result in one watt of electrical energy developing 30 to 50 lumens, which, at the present cost of electrical energy, will mean 3,000 candle-power-hours for one penny, even when using small units.

This leads me to a subject which deserves our careful consideration, namely, that energy in the form of light is rapidly becoming so inexpensive that it is time such energy was more promiscuously used to brighten the lives of those whose circumstances and surroundings are now so dull that they live in depressed mental and moral condition.

This is the work before illuminating engineers, and I want you to consider for a few moments what

it means. Unfortunately, all the factors which control it are not in your hands, but it is our duty to take advantage of those which are, and not to consider only the factor of illumination on a screen, but more the production of visibility and brightness.

As you are well aware, inventors, physicists and others will go on improving the efficiency of light-production, but this is of little good if such light is not used to advantage: for example, what use would it be to produce thousands of lumens in a room in which the walls, ceilings and contents had no reflecting value? Those who have had the opportunity of entering a large "Ulbricht" sphere such as I have been using, coated as it is with a white wash having a reflecting value of nearly 90 per cent., cannot fail to have felt a sensation which can hardly be described, but certainly is pleasing, and there is no doubt there are thousands of people who are now despondent and depressed to the extent that their health and the health of their children is suffering; who, if they could live among surroundings of this nature, combined with an ample supply of luminous energy, their lives and outlooks would be both brighter and happier.

It is perhaps unfortunate that the title of "Illuminating Engineer" was ever given to this and kindred societies, for the reason that such a title is liable to make many members think that their work is completed when they prove by means of a photometer and highly reflecting screen that the illumination is high; such a screen would often be of more practical value if it had the same albedo factor as the surroundings or objects it was desired to make visible, thus registering the luminous energy reflected.

If, for example, in street lighting, when using that type of portable photometer embodying a separate screen, the black or dark surface of the road were balanced against the standard screen of the photometer, thus measuring the light actually reflected, the result would be dissatisfying in the case of the majority of our present road surfaces. Class "A" of the British Standard Specification would often be found to fall below Class "H." Even the knowledge of the amount of luminous energy which falls on the area to be illuminated gives very little information beyond the average illumination, which information is often misleading, as even when the average is high the illumination may fall to an infinitely small degree over some part of that area. There is no doubt that in order to define, or specify, the value of an artificial lighting installation, it is necessary to fall back on more than one factor.

This phase of the lighting problem has been most carefully investigated by the British Standard Street Lighting Committee, whose labours, as you probably know, are still unfinished. In the case of interior lighting, such as factories, schools, etc., the illumination on the working plane (nearly always taken as horizontal) appears to have satisfied the majority in spite of the fact that it was often proved very misleading in practice. The more careful illuminating engineer is now considering the illumination on other planes than the horizontal. Street-lighting engineers throughout the world are still far from satisfied as to the best method of comparison and grading. Mr. Trotter's Joint Committee of 1913 (previously referred to), was not entirely unanimous on the question of minimum horizontal

illumination for the purpose. In his paper before this Society he states: "The Institution of Gas Engineers, while fully appreciating the valuable work which has been done, regretted they could not agree with the fundamental basis of the suggested specification, namely, the stipulation of the illumination with a stated foot-candle minimum measured on the horizontal plane. The Joint Committee in these circumstances, were reluctant to take any further steps until an attempt had been made to review the problem and to give an opportunity for a full debate upon it."

This opportunity followed his paper in the form of a discussion, but little came of it. The British Standard Street Lighting Specification Committee commenced its work in 1925, has been debating at short intervals ever since, and it is largely due to Mr. Paterson's genius as a chairman that anything has ever come of that. He has been the first to admit that the specification already issued must be subject to constant revision as the problem is still unsolved. This specification still remains the only useful instrument of its nature which can be said to be of practical value.

*Nil desperandum* must always be the motto of conscientious illuminating engineers. It has been said that physiology and psychology enter into the problems with which they have to deal, as much as physics; this is so true that in the practice of illumination one has often a tendency to despair.

Luckeish described illuminating engineers as those who should be proficient in the "Science of Seeing." This is indeed its main object. But I think it has a further one which must not be overlooked, namely, that of producing brightness. Our technical publications are full of descriptions of lighting installations in public buildings, theatres, churches, only used by certain sections of the people on comparatively rare occasions, but how often does one read about any means for brightening the homes of those who have little choice in these matters? This subject has been referred to before in this address, but it seems so important to me that I feel certain you will forgive me for emphasizing it again. Nobody knows better than an illuminating engineer the effect of bright surroundings on the lives of those who must needs live a somewhat dreary and monotonous existence because their work is becoming more mechanical and less interesting every year. The majority of such people return every day to houses which in the many dark months of the year, built on a standardized plan, are even more monotonous than their work and the workshops or offices in which they do it. Who can alter this without great expense? I venture to suggest that it is within the power of illuminating engineers, with the help of lighting contractors and others connected with the supply of lighting fittings.

Such fittings are like everything else, a matter of mass production, and naturally bear a marked similarity as regards their general construction, but the shades and those parts which actually affect the eye, both as regards colour and light distribution, can be made to vary the effect considerably. A move has lately been made in the right direction inasmuch as gas and electricity undertakings are now providing showrooms where there is a choice for certain classes of people. On the other hand, in many places the only stock, and often the best selection, of shades is available at a local store at the modest price of sixpence each. There is of course no

objection to this, nor to the fact that the people are taken by the bright colours and shape of such shades which are designed to catch the eye, but it should be remembered that in many cases, when they are not even lined with a reflecting surface, they do not in any way direct the light, but only absorb it and thus reduce the illumination. It is true that light energy is cheap; but not so cheap that the class of whom I am referring can afford to use it indiscriminately. An illuminating engineer could often produce a much brighter and healthier result without increasing the lighting bill, but he is rarely consulted by the producers of this class of lighting attachment.

I submit that the manufacturers should produce and the retailers exhibit in their windows, and sell from stock over their counters at a price within the means of these people, attractive and efficient shades and reflectors, which may not last for ever, but do add to the brightness of these millions of homes, and of the work-rooms and places where the people work.

That such appliances should not last for ever might prove a good feature, as they would then be periodically changed and the brightness renewed, the periodic cleaning of the more permanent type being often overlooked.

Such a proposal does not appear difficult to carry out if its object is kept clearly in view, and all the parties concerned continue to encourage the principle of increased brightness everywhere. "Increasing your illumination" are words not understood by everybody, and need not necessarily mean increased brightness, but in order to render the plan successful their meaning must be made very obvious to all observers.

The same applies to our streets; the public must be led to help themselves, instead of acting as obstructionists, as at present they often do. It is admitted that the best and most economical way to improve the illumination and brighten up a street is to have as many lighting points as possible; that is, to reduce the spacing; but the cost of extra standards, the accidents caused by them, added to the cost of underground services and means of lighting and extinguishing when individually connected to the ordinary service mains often prevent anything being done in the matter. If the public or their representatives in municipal matters were made to realize that this reduced spacing and removal of obstacles could be inexpensively carried out by making use of existing buildings as fixtures for the lighting units, much could be done. The very people permitting these fixtures would benefit even more than their fellows, yet we are told that they are the first to object. There can be only one reason for this, namely, that the case has not been put before them clearly and in the true public spirit, nor have they been made to realize the many advantages which would result.

In this address I have attempted to place before you not only a historical record illustrating the trend of industry with which we are connected, but certain simple facts with which we are now confronted, the most important of which is that we must bring home to fellow-creatures how necessary it is that they should help us in order to help themselves.

We, as illuminating engineers, are prepared to do our best to brighten the lives of all those who wish to disperse the gloom which so often exists, but we must have the co-operation of our fellow-men, just as the doctor must be backed up by the desire of his patient to live. The work will then result in the attainment of our ambition, namely, the brightening of the lives of all mankind

## Progress in Illumination

(Report prepared by the Technical Committee of the Illuminating Engineering Society: Mr. A. W. Beuttell (Chairman), Mr. H. Buckley, Mr. J. S. Dow, Dr. S. English, Lieut.-Commander Haydn T. Harrison, Mr. Wm. Millner, Mr. E. L. Oughton, Mr. Howard Robertson, Mr. J. C. Walker, Mr. H. C. Wheat; Co-opted: Mr. W. J. Jones, Mr. C. A. Masterman, Mr. T. E. Ritchie, and Mr. G. H. Wilson; presented at the Opening Meeting, held at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, at 6-30 p.m., on Tuesday, October 11th, 1932.)

### INTRODUCTION.

THE report now presented is the third undertaken by the Technical Committee, which has followed the methods of assembling information adopted in 1931.<sup>1</sup>

The report has again been confined to papers and events during the year ending August 31st, 1932, and is devoted mainly to progress in Great Britain. In view of the industrial depression that has prevailed during the past year it is perhaps hardly surprising that there are no very radical advances to record; though in many directions steady progress may be recorded.

### GAS LIGHTING.

The developments in gas lighting recorded in previous reports have been extended. Greater use is now being made of methods of distant control, such as the use of positive gas switches, which are now made to operate without the necessity of a gas bypass flame. Greater attention has also been paid to the preparation of mantles for special purposes. The "daylight" gas mantles devised to facilitate colour-matching processes are becoming more widely used. Gas lamps equipped with special mantles utilizing the infra-red rays are also being much used by the medical profession in therapeutic work.

A feature in connection with street lighting has been the further development of lanterns equipped with directive reflectors of stainless steel or with prismatic glass refracting devices. Considerable progress is also being made in the application of gas lighting in various forms of traffic and direction signals used in streets. A tendency to make fuller use of special types of reflectors for interior lighting is also evident. Decorative panel and ceiling lighting by gas is making considerable progress. Special units comprising concentrating trough reflectors placed above a row of mantles are finding many applications where intense local illumination is desired.

Perhaps the most noteworthy development has been the extension of floodlighting with gas, following the display at the International Illumination Congress last year. Special forms of projectors are now being applied to illuminate buildings, gardens and dancing by night. The recent floodlighting of St. Mary's Abbey, York, and other picturesque ruins, on the occasion of the meeting of the British Association, was a notable instance, nearly 100 projectors being used for this display.

### ELECTRIC INCANDESCENT LAMPS.

Development in incandescent electric lamps has proceeded systematically during the past twelve months under review. The systematic change-over from clear-bulb lamps to pearl and opal types is reflected in the statistics for the period, and indicates that users are becoming better acquainted with the advantages of these lamps in overcoming glare.

#### Greater Consistency of Product.

During the period under review the leading lamp manufacturers have concentrated their attention upon the problem of securing even greater con-

sistency of performance in their products, and the outcome has been a further reduction in the close manufacturing tolerances previously obtaining. As a result, a batch of incandescent lamps to-day shows considerably less individual excursion from the average performance in light-output, consumption, life and lumen maintenance throughout life, thus ensuring distinctly superior lighting service in all fields of application. It is estimated that 80 to 90 per cent. of standard types of lamps attain the specified light-output, lasting 800-1,600 hours.

#### Changes in Dimensions.

The British Standard Specification No. 161 for tungsten-filament electric lamps has been revised during 1932, and shows certain changes in dimensions for some of the general service lamps. These changes have been effected with the object of conforming to international standards, and concern gas-filled lamps from 150 to 1,500 watts. In certain cases reductions have occurred in overall length, diameter of bulb and light-centre length.

#### New Forms of Lamps.

A feature has been the extending use of tubular forms of incandescent lamps. The introduction of new tubular lamps with filaments running up to the ends has rendered "gapless" lines of light a possibility.

Photographic lighting equipment has been advanced by the introduction of a new type of safety flashlight, which is a definite improvement over the old type of magnesium-powder flashlight. It consists of a glass bulb containing oxygen and some very thin aluminium foil. The foil is connected by two lead-in wires to a cap, by which it is possible to heat up the foil by a current from a small dry cell. This causes ignition—the aluminium burning almost instantaneously with a brilliant white light.

### VAPOUR LAMPS.

Considerable interest has been taken in the development of lamps using luminescent vapours or gases. In connection with neon lamps new shades of colour have been introduced and the brilliancy of existing colours has been improved. Such lamps are now being more widely used to supplement incandescent lamps. Flashing and animated effects are being produced in connection with luminous signs.

A development of considerable interest is the hot-cathode discharge tube, 400 watts being consumed in a column of vapour about 6 ins. long, which is operated directly on a 230-volt supply. It is estimated that three times the efficiency attainable from ordinary lamps can thus be obtained, and lamps based on this principle will find applications for exterior lighting, and in other cases where the colour of the light is not regarded as a serious drawback.

### LIGHTING ACCESSORIES AND EQUIPMENT.

During the year under review, new developments in lighting accessories and equipment have not been numerous or of outstanding importance; most manufacturers appearing to have concentrated on improving their existing lines and adapting them to meet changing conditions.

<sup>1</sup> *Illum. Eng.*, Dec., 1931, pp. 304-310.

### Glassware.

In the manufacture of glass for lighting fittings, British manufacturers are now in a position to supply either solid or cased opal glass with low light absorptions and good diffusing powers; a new type of mottled or "flake" opal is also being produced. The building up of lighting units from sprayed or enamelled sheet and moulded glass of various shapes continues, and much ingenuity is displayed in the means adopted for securing such separate pieces of glass into a reasonably robust fitting. A new type of enclosing prismatic glass unit with a completely smooth exterior has been introduced. Fused quartz in new designs suitable for use with either gas or electric light-sources, e.g., octagonal and hexagonal bowls in the natural semi-opaque white or tinted, are now available.

### General Fittings.

Among lighting fittings, several new bulkhead units of various types have been introduced; besides new members of the sturdy type, employing prismatic front glasses, lighter types of casings have been developed—e.g., pressed steel or moulded bakelite.

To meet the Home Office requirements concerning the use of E.S. and G.E.S. lampholders, besides the skirted types which have long been available, insulating skirts for attaching to existing holders have recently been introduced.

### Street-lighting Fittings.

In street-lighting fittings the development of "directional" lighting units continues, and different prismatic glass units are now marketed by several of the leading firms interested in street lighting, two of the most interesting of the recently introduced designs being respectively: (1) a single-piece dome refractor embodying step lenses on opposite sides and (2) a two-piece directional glass reflector, the inner member of which throws the main beams down rather steeper than most refractors, and also hides the light-source from view for about 10° below the horizontal, thus avoiding troublesome glare. At the same time, the outer diffusing envelope has a low luminosity, permitting sufficient light to pass to avoid the "tunnel" effect.

In street lighting with gas the use of mirrors of various kinds and of refractors of heat-resisting glass has been extended by the introduction of new types of equipment.

### Traffic Control.

Apparatus for the control of street traffic by light signals has been developed still further, and two interesting modifications of the optical system have been introduced. In one type the advantages of the lens system in giving a strong main beam is combined with the good points of the reflector-diffusing roundel system in giving a widespread indication by employing the former for the upper half of the signal glass and the latter for the lower half. In the other system a colourless curved lens, with prisms on the side remote from the source of light, is used in combination with a coloured glass screen in such a way that the exposed surfaces of the combination are perfectly smooth, thus reducing maintenance costs to a minimum.

### DOMESTIC AND OFFICE LIGHTING.

The modern movement in the design of lighting and lighting fittings has proved by its further development in the past year that it is by no means a fleeting fashion. The exaggeration and crudeness of earlier essays have largely disappeared, the jagged, odd-glass shapes having given place to

rounded forms with spheres, cylinders and simple bends held in position with an efficient and effective minimum of smooth-surfaced metal.

There is a tendency towards simplicity of design and "fitness for purpose."

The past year has been marked by the ever-spreading use of well-designed, simple, enclosed units, which are efficient in use, low in price, easy to maintain, and yet are in keeping with the progressive movement in architecture and interior decoration and furnishing.

The tubular lamp and the forms of fittings that it has inspired have been widely employed with useful and decorative results, and there is a present activity in the perfecting of long tubular lamps giving the uninterrupted line of light with economy of space that is so useful in modern architecture.

### PUBLIC LIGHTING.

The International Illumination Congress last year gave our foreign visitors and some of our public lighting committees and engineers the opportunity to see the most striking examples of street lighting in London and other cities of England and Scotland.

The Congress introduced an international note into the papers and discussions of its street-lighting sessions, which were also the Annual Conference of the Association of Public Lighting Engineers.

During the year following the Congress there have been further improvements of installations, and some have been provided in the higher classes of the British Standard Specification for Street Lighting.

The Specification has provoked lively discussion, and a committee has been at work upon a further revision. The Specification certainly has stimulated the gathering of much helpful information, and its simpler provisions have been more and more adopted. The standard of maintenance has also improved.

Multiple horizontal gas burners with pre-heaters continue to take the place of one-light upright-inverted burners in square lanterns. Clusters of 4-15 mantles with round globes are substituted for many square lanterns. Bijou and medium-size mantles now replace the larger size. Electric lamps of 150-watts and upwards are more widely used, and 100-watts tend to become the minimum.

Mounting-heights have been increased, and this increase has been accompanied by a rise in the total luminous flux per lighting-point. Directional reflectors and refractors are becoming more frequent with electric lamps and with both high- and low-pressure gas lamps.

The relation between lighting and road safety was explored by papers prepared by the Association of Public Lighting Engineers, and reported, with discussion, in the journal of the Society.<sup>2</sup>

Public lighting departments, in opening new premises, have included photometric and other testing rooms.

Other developments of the year are to be found in the reports of members of the Association of Public Lighting Engineers submitted at the recent Conference in Blackpool (September 5th-8th, 1932), and in the papers presented at this Conference.<sup>3</sup> The latter dealt with The Administration of Public Lighting, Problems in Towns of Moderate Size, and The Planning of Gas and Electric Lighting Installations to conform with the British Standard Specification—a feature being the application of the isocandle diagram.

New gaseous electric lamps, at present in the experimental stage, may prove to have a very con-

<sup>2</sup> *Illum. Eng.*, Jan., 1932, p. 21; June, 1932, p. 153.

<sup>3</sup> *Illum. Eng.*, October, 1932.

siderable influence on public lighting. An installation of the type of lamp utilizing sodium vapour has been erected in Holland. Experimental gas-discharge lamps were also fitted up in a street in Wembley on June 22nd.

#### RAILWAY LIGHTING.

##### *Surface Railways.*

The most important development during the year has been the further use of floodlighting by gas or electricity for shunting-yards. On one railway 15 new schemes of lighting with projectors have been put forward. A large installation comprising 60 projectors is being prepared for Swansea. It is interesting to note that a circular enquiry addressed to the operating officers of one of the railways has elicited unanimous agreement that floodlighting is the best form of lighting yet introduced for railway-yard work.

Another type of installation has been adopted in a reconstructed goods yard in London, in which directional lighting has been combined with local lighting by means of reflectors having dual beams. The yard in this case consisted of sidings and cart roads, and it was desired to avoid obstructing the latter with posts. The lighting was entirely arranged from the sides and ends of the area concerned. Directional lighting for platforms mentioned in the previous report has been further extended, and may now be said to be standard practice on the Great Western Railway, whether the source of light is electricity, gas or vaporized oil.

Attention may be directed to a very adaptable form of paraffin-vapour lamp which can be suspended from the ceiling or fixed in a wall-bracket or can be used as a standard lamp.

On account of the considerable saving that can be made without reducing the efficiency of the lighting when actually required, much attention has been given to switching and distant control for gas lighting. The reliability of such devices for railway use has now been firmly established. Experiments are being made with the use of photo-electric cells for the automatic control of lighting in a large signal-box, and also on a platform.

##### *The Underground Railways.*

Undoubtedly the outstanding feature of the lighting of the Underground Railways during the past year has been the adoption of "architectural" lighting, and the building of the Southgate extension and the rebuilding of many other stations—totalling about 30 stations—has offered a very good opportunity for trying out many new ideas. The main object has been, not so much to effect large increases in lighting intensities, but to improve the appearance of booking-halls and platforms and to make them cheerful and inviting. At Marble Arch and Hyde Park Corner stations, for instance, the new underground booking-halls have been illuminated by means of continuous pressed-glass "luminous beams" following the contour of the walls. This concentration of light round the sides of the booking-hall produces an effect of spaciousness.

On the new Southgate extension tunnel station platforms the section of the tunnel has been altered so as to form a continuous soffit on either side at a height of about 10 ft. 6 ins. above the platform. Small pressed-glass rectangular fittings are recessed into this soffit over both the platform and the track at a distance of about 7 ft. apart, making a total of about 120 fittings per platform, and the resultant lighting is very even indeed.

#### LIGHTHOUSE ILLUMINATION.

On the question of lighthouse illumination, the

year has not produced any remarkable developments. There have been several papers during the year of more than usual interest, which is exceptional as far as this particular branch of the subject is concerned. The International Commission on Illumination produced two papers, one<sup>4</sup> a mathematical discussion on lighthouse optics, and the other<sup>5</sup> of more general interest. In December, 1931, a paper on the Development of Lighthouses<sup>6</sup> was given to the Royal Society of Arts by D. Alan Stevenson, and recently Langmuir and Westendorp have reported on an extended series of experiments they have carried out on the subject of the Visibility of Light Signals.<sup>7</sup>

#### AVIATION LIGHTING.

Since it is not economically possible to produce a beacon which combines in itself all the desirable features of the several types available, experiments have been carried out to determine the relative importance of various beacon characteristics. One of the conclusions drawn from these tests is that signal intensity is of greater importance than signal character. As a result of the tests, it has been decided to install several powerful single-flash beacons on the Croydon-Lympne airway.

Croydon airport has been equipped with a series electric boundary-lighting system, using 6.6 ampere, 600-lumen lamps enclosed in orange-coloured globes. The circuit is controlled by a flasher which switches on for  $\frac{1}{4}$ th second, and off for the same period.

A system of aerodrome floodlighting has been developed which promises to be reliable, efficient and inexpensive. A standard 10 kw. third order dioptric floodlight can be used, permanently installed in a position from which it illuminates the whole landing area. The objection hitherto to making the floodlight a fixed installation is that the direction of landing is dependent on the direction of the wind, and the pilot would therefore on occasion have to land into the beam, facing the full glare of the light.

This difficulty has been overcome by the use of a vertical shutter which can be swung about the lens axis, completely screening the flashed portion of the lens over a small dihedral angle. The movable shutter is placed sufficiently far away from the lens to give a sharply defined "shadow bar" across the illuminated surface of the aerodrome. When an aircraft is landing the floodlight operator keeps the shadow bar on the machine by suitable movement of the shutter, so that the source of light remains entirely invisible to the pilot while the ground he is approaching is brightly illuminated.

Improvements have been made in the performance of the port and starboard navigation lamps carried by aircraft by the adoption of selenium glass domes to obtain light of the required colours. The high transmission of this glass has enabled the weight and power consumption of the navigation-light system to be materially reduced without decreasing the range of visibility of the lights.

#### ILLUMINATED SIGNS.

Developments during the past year might very definitely be divided into two classes, in so far as illuminated signs are concerned: (1) a greater and

<sup>4</sup> "Brilliance apparente des surfaces de sortie des appareils optique eclaires par des sources de lumiere." A. Blondel. Proc. Int. Comm., III, 1931, pp. 528-538.

<sup>5</sup> "Lighthouses." J. P. Bowen. *Ibid*, pp. 985-998.

<sup>6</sup> "The Development of Lighthouses." D. Alan Stevenson. Roy. Soc. Arts. Vol. LXXX, No. 4130. January, 1932, pp., 223-242.

<sup>7</sup> "A Study of Light Signals in Aviation and Navigation." Langmuir and Westendorp, Physics, Vol. I, No. 5, pp. 273-317.

wider use of gaseous-discharge signs, (2) signs giving similar effects with the use of lamps.

Neon has made great strides, particularly in design and application during the year under review, and great use is now being made of it for giving decorative effects, such as the outlining of buildings and ornamental designs, baskets of flowers, etc., similar to those to be seen at the *Daily Express* new building in Fleet Street.

Animated effects, also in neon, are beginning to appear, and interesting results may be seen on the Pavilion Theatre and Sout sign in Trafalgar Square.

Another step forward has been made in interchangeable letters, for which there is a large field for theatres and cinemas; a particularly good example of this work may be seen at the Victoria Palace, where a uniformly illuminated background has also been provided by a system of parallel louvres, each louver concealing a tube which illuminates the louver above it.

Signs giving gaseous-tube effects such as moulded acetate letters and glass panels with special treatment are now to be seen, and can be produced on mass-production lines.

#### INDUSTRIAL LIGHTING.

Statistical investigations conducted by Mr. P. E. Shopland,\* one of H.M. Inspectors of Factories, confirms the impression that in some areas progress made since the compilation of a similar series of data, about twenty years ago, is disappointing. Thus, in more than 200 factories visited in the ironfounding, light engineering and textile industries, few really satisfactory installations were found. Glare was prevalent. More than half of the readings only attained 1.5 foot-candles or less, only 11 per cent. attaining 5 foot-candles or more. It is mainly in the case of old factories and in industries which have been passing through difficult times that disinclination to install modern equipment is manifest. In newly erected factories conditions are usually much better, and some admirable installations are being made. It is also encouraging to observe that, according to the reports of the Chief Inspector of Factories, managers on the whole show greater appreciation of the value of good lighting; deficiencies are due either to lack of knowledge or to inability to make the necessary expenditure.

#### FLOODLIGHTING.

There has been no pause in the developments in floodlighting. In a great many cases newly erected buildings have been equipped at the outset with a floodlighting installation. Unilever House may be mentioned as an example in the Metropolis, but there are many more similar installations throughout the country. This development is particularly noticeable to users of the main through roads in all parts of the kingdom, for almost every new roadside inn, and many of the larger petrol-filling stations, are now thus illuminated.

Of the many places of historic interest which have been floodlighted during the past year, Fountains Abbey may be mentioned.

The units themselves continue to be improved in regard to mechanical construction, and a new type of floodlight giving a flat fan-shaped beam has been introduced.

Another new type of floodlight which has been introduced gives a wide beam for close-up work which is produced by means of prismatic reflecting-glass plates.

Another ancient monument recently floodlighted is Whitby Abbey. This old abbey, situated as it is on a hill, stands out well when illuminated, and is a landmark for a considerable distance. The installa-

tion on Edinburgh Castle has now been made permanent.

During the past summer the increased interest in swimming and bathing has been responsible for many successful floodlighting installations at swimming baths and sea-bathing beaches.

#### PHOTOMETRY AND COLORIMETRY.

No very marked advances in photometry and colorimetry are to be recorded, though the number of papers published during the last twelve months indicates that steady progress is being made.

Important papers on photometry and allied subjects have been presented at a number of congresses held during the year. Foremost among these were the contributions to the International Commission on Illumination, at Cambridge, last year, of which some mention was made in the report for 1930-31. In June last the Optical and Physical Societies organized a discussion on colour vision, at which about 20 papers were read. A summary of these appeared in the August issue of *The Illuminating Engineer*. Several papers on photometry and illumination were presented at an International Congress on Electricity, held in Paris in July. One of the most interesting was by Dziobek,<sup>9</sup> on the present status of the units of candle-power. It is interesting to note that Germany intends to abandon the Hefner candle in favour of the International candle.

Much attention is still being devoted to the use of photo-electric and rectifier cells in physical photometry and in spectrophotometry, particularly in the ultra-violet region of the spectrum. Photo-electric recording of daylight at the National Physical Laboratory formed the subject of a paper by McDermott and MacManus.<sup>10</sup> A new photo-electric spectrophotometer has been devised by Smith and Holiday<sup>11</sup>, while the Spekker modification of the Hilger ultra-violet spectrophotometer has been described by Twyman<sup>12</sup>, who has also, in collaboration with Spencer and Harvey<sup>13</sup>, developed a rapid method of ultra-violet spectrophotometry in which a new type of wedge-shaped cell for liquids is employed. Instruments for the measurement of the brightness of radio-active material have been described by Meacock and Lambert<sup>14</sup>.

The subject of daylight illumination has received considerable attention. Two papers by Stevenson<sup>15</sup> and <sup>16</sup> deal with the photographic and visual determination of daylight factors, and with the determination of the periods of sunlight penetration into interiors. Methods of deriving the same information have also been described by Beckett and Dufton<sup>17</sup>, while a photographic daylight recorder has been described by Cooper and Sayce.<sup>18</sup>

Colorimetry has also received considerable attention, both in connection with the discussion on colour vision and in other papers. As mentioned in last year's progress report, the 1931 meeting of the International Commission on Illumination resulted in the international adoption of standard data and standard methods for colorimetry. Smith and

\* *Illum. Eng.*, May, August and September, 1932.

<sup>9</sup> Cong. Int. d'Elect., Paris, 6e Section Rapport 1, 1932.

<sup>10</sup> *Illum. Eng.*, XXIV, p. 41, 1932.

<sup>11</sup> Trans. Opt. Soc., XXXIII, p. 20, 1931-32.

<sup>12</sup> Trans. Opt. Soc., XXXIII, p. 9, 1931-32.

<sup>13</sup> Trans. Opt. Soc., XXXIII, p. 37, 1931-32.

<sup>14</sup> Journ. Sc. Inst., VIII, p. 214, 1931.

<sup>15</sup> Journ. Sc. Inst., II, p. 96, 1932.

<sup>16</sup> Journ. Sc. Inst., IX, p. 222, 1932.

<sup>17</sup> Journ. Sc. Inst., IX, p. 158, 1932.

<sup>18</sup> Journ. Sc. Inst., IX, p. 282, 1932.

Guild<sup>19</sup> have described the origin and use of these standards, and a new trichromatic colorimeter has been devised by Houston.<sup>20</sup>

Progress abroad seems to be very much on the same lines as in Great Britain. No very important new theoretical developments have appeared, but progress has been, as in Great Britain, mainly in connection with photometric measurement.

#### MISCELLANEOUS RESEARCH.

Investigations of the effect of glare on the brightness difference threshold with white and coloured lights have been continued at the National Physical Laboratory, and a second glare meter has been designed and constructed. Work has also been undertaken on the effects of glare from motor-car headlights.

The problem of light diffusion by opal glasses continues to receive attention. Investigations in progress at the National Physical Laboratory lead

to the hope that in due course it will be possible to deduce all the main properties of an opal glass from a knowledge of its microstructure.

Various forms of photo-electric photometer have been devised during the past year, and, in addition, investigations have been undertaken into the characteristics and uses of the cells apart from photometry.

The Technical Committee desires to acknowledge assistance received from the following: Mr. L. E. Buckell, Mr. J. C. Christopher, Mr. A. Cunningham, Mr. H. N. Green, Dr. W. M. Hampton, Mr. H. C. Ridge, Mr. W. H. Seward, Mr. E. J. Stewart and Mr. H. T. Young.

Information has also been obtained from "Literature on Lighting," published monthly in *The Illuminating Engineer*, to which those interested may be referred for fuller details of developments.

<sup>19</sup> Trans. Opt. Soc., XXXIII, p. 73, 1931-32.

<sup>20</sup> Trans. Opt. Soc., XXXIII, p. 199, 1931-32.

## Literature on Lighting

(Abstracts of recent articles on Illumination and Photometry in the Technical Press)

(Continued from Page 271, October, 1932).

Abstracts are classified under the following headings: I, Radiation and General Physics; II, Photometry; III, Sources of Light; IV, Lighting Equipment; V, Applications of Light; VI, Miscellaneous. The following, whose initials appear under the items for which they were responsible, have already assisted in the compilation of abstracts: Miss E. S. Barclay-Smith, Mr. W. Barnett, Mr. S. S. Beggs, Mr. F. J. C. Brookes, Mr. H. Buckley, Mr. L. J. Collier, Mr. H. M. Cotterill, Mr. J. S. Dow, Dr. S. English, Dr. T. H. Harrison, Mr. C. A. Morton, Mr. G. S. Robinson, Mr. J. M. Waldram, Mr. W. C. M. Whittle and Mr. G. H. Wilson. Abstracts cover the month preceding the date of publication. When desired by readers we will gladly endeavour to obtain copies of journals containing any articles abstracted and will supply them at cost.—ED.

### II.—PHOTOMETRY.

#### 257. A Photographic Daylight Recorder. J. Omer Cooper and Leonard A. Sayce.

*Journal of Scientific Instruments*, Vol. IX, No. 9, p. 282, September, 1932.

The paper describes a simple apparatus for measuring the diurnal variations of daylight.

W. B.

#### 258. A Photographic Method of Determining Daylight Factors and Periods of Insolation. H. E. Beckett and A. F. Duffon.

*Journal of Scientific Instruments*, Vol. IX, No. 5, p. 158, May, 1932.

A photographic method is described whereby daylight factors and periods of insolation can be determined within existing buildings. Projections upon a vertical cylinder of the outlines of windows and external obstructions are obtained with the aid of a pinhole camera, and are subsequently interpreted by the superposition of appropriate diagrams. Full directions for the construction of the latter are given.

W. B.

#### 259. On the Penetration of Direct Sunlight into Interiors. A. G. Stevenson.

*Journal of Scientific Instruments*, Vol. IX, No. 7, p. 222, July, 1932.

Auxiliary grilles are described for use with the Swarbrick photo-theodolite (or with a camera in a more limited way) by means of which the duration of possible direct sunlight visible from a given point in an interior is made evident by the superposition of the grilles upon the photographs of apertures taken with the instrument. The grilles give information as to the apparent solar times during which it is possible for direct sunlight to reach the point at different periods of the year. The use of the gnomonic projection in connection with the geometrical solution of associated problems is discussed.

W. B.

#### 260. Light Reflecting Characteristics of Paints. D. L. Gamble.

*Ind. and Eng. Chemistry*, Vol. 24, No. 8, p. 875, August, 1932.

Records measurements of specular and diffuse reflection factor of paint samples, and discusses briefly the mechanism of reflection by paints. Describes a series of experiments on the distribution of illumination in a model room with surfaces of different characteristics and with different lighting systems. The effect of the walls alone is investigated; the distribution has markedly different characteristics when specularly reflecting walls are used.

J. M. W.

### III.—SOURCES OF LIGHT.

#### 261. The Carbon Arc as a Source of Artificial Sunshine, Ultra-violet and other Radiation. C. E. Greider and A. G. Downes.

*Am. Illum. Eng. Soc., Trans.* 27 pp. 637-653, Sept., 1932.

Data on the more common types of carbon arc lamp are presented, together with typical energy-distribution curves. A description is also given of the conditions under which each type of arc operates with respect to its own particular field of application, for industrial purposes as well as a source of ultra-violet radiation for the maintenance of health.

G. H. W.

#### 262. The High-intensity Arc as a Projection Source. P. R. Bassett.

*Am. Illum. Eng. Soc., Trans.* 27, pp. 623-636, Sept., 1932.

The paper describes the changes in the form of the carbon arc as the current is increased until the high intensity type of arc is formed. Some applications are briefly described.

G. H. W.

**263. A Method for Determining the Most Favourable Design of Gas Burners. John H. Iseman.**

*Bureau of Standards Journal of Research, Vol. 8, No. 6, p. 699, June, 1932.*

The conditions which limit the satisfactory operation of a gas burner in its relation to the appliance are briefly discussed. Definite limits may be determined which show the conditions under which the flames flash back or blow from the ports and those under which combustion is rendered incomplete or "carbonizing" flames are produced. The relationships between these limiting conditions and several of the more important details of design and adjustment of the appliance are shown for the typical case of the top burner of a gas range burning a carburetted water gas of 570 B.t.u. The effects of the more important possible changes on the efficiency and rapidity with which heat is transferred are also shown and the most favourable combination of conditions is systematically developed. The effects of the allowances which must be made in design for anticipated variations of pressure and inaccuracy of adjustment are also shown. An appendix describes the laboratory apparatus which has been developed for experimental work of the kind involved.

W. B.

**264. New Design of High-wattage Incandescent Lamps. D. K. Wright.**

*Gen. El. Rev. 35, pp. 532-4, October, 1932.*

The copper thimble type of lead-in seal has been made on an automatic machine and is applied to high-wattage lamps. This permits pre-focussing and avoids the necessity for a cap.

G. H. W.

**IV.—LIGHTING EQUIPMENT.****265. Commercial and Domestic Lighting Fittings. Anon.**

*El. Times 82, pp. 363, 364, 938, Sept. 22nd, 1932.*

Gives illustrations and descriptions of this year's newest commercial fittings for domestic applications and for shop, hospital and similar lighting schemes.

G. S. R.

**266. Modern Lighting. Anon.**

*El. Rev. III, p. 572-9, October, 14th, 1932.*

Gives three pages of illustrations together with descriptions of modern lighting fittings by leading manufacturers.

G. S. R.

**267. Developments in Glassware used for Railway Signalling. W. M. Hampton.**

*World Power 18, pp. 227-229, October, 1932.*

The paper records the development of stepped lenses for railway signal work that has followed the general adoption of electric lamps as a source of light.

C. A. M.

**268. Novalux Enclosed Copper-oxide Cutouts for Series Street Lighting Circuits. H. E. Butler.**

*Gen. El. Rev. 35, pp. 535-6, October, 1932.*

A new copper-oxide cutout is described. The oxide-coated disc is enclosed in a two-part aluminium jacket. Three sizes are made.

G. H. W.

**V.—APPLICATIONS OF LIGHT.****269. Light and Architecture. Anon.**

*Am. Illum. Eng. Soc., Trans. 27, pp. 601-610, Sept., 1932.*

Eight illustrated descriptions of modern lighting installations.

G. H. W.

**270. Custom-built Lighting Enters the Home. I. C. Wood.**

*Am. Illum. Eng. Soc., Trans. 27, pp. 611-622, Sept., 1932.*

Deals with built-in lighting units applied to the home. All the rooms in the home are discussed and drawings and photographs show the methods of construction and the effects produced.

G. H. W.

**271. A Review of Modern Design. C. T. Masterman.**

*Light 2, No. 8, pp. 9-11, September, 1932.*

Photographs are reproduced giving examples of modern architectural application of lighting. A number of proposals for the forthcoming Chicago exhibition is included.

C. A. M.

**272. Short Cuts In Illumination Design. H. Lingard.**

*El. Times 82, pp. 359-360, September 22nd, 1932.*

A table of recommended illumination values for different types of industrial and other requirements is presented. Other tables specify the Room Index and coefficient of utilization for various fittings with a view to facilitating illumination design.

G. S. R.

**273. Intensity of Illumination. A. Alison.**

*El. Rev. III, p. 572, October 14th, 1932.*

A method of solving illumination problems is given, based on the formula Foot-candles  $\times$  area in sq. feet = 3.75 (watts)<sup>1.125</sup>. A nomogram is given for graphical solution.

G. S. R.

**274. Industrial Lighting Installations. Anon.**

*El. Times 82, pp. 361-2, September 22nd, 1932.*

Gives two pages of illustrations and recommendations and discusses the problems which arise in connection with the lighting of different types of factory.

G. S. R.

**275. Better Lighting for Hotels. "Megohm."**

*El. Times 82, pp. 394 and 397, Sept. 29th, 1932.*

Statistics taken of hotel lighting all over the country indicate that the average hotel is very inadequately lighted. It is stated that the cost of flood-lighting the building front is not large and that this should be done whenever possible. The various fields of lighting in the hotel are discussed.

G. S. R.

**276. Subway Lighting in Paris. Anon.**

*El. Rev. III, p. 497, October 7th, 1932.*

The lighting of the new subway at the Porte Dauphine is so designed that the users shall not find too great a difference between the light outside and that underground. The subway is 820 ft. long and there are four circuits containing 242 500-watt lamps. A photo-cell situated outside the tunnel operates control gear which switches on one or more circuits according to the amount of daylight falling on the cell.

G. S. R.

**277. A Basis for Street-lighting Schedules. P. R. Knapp.**

*El. World 100, pp. 404-5, September 24th, 1932.*

Describes the method of arriving at a time schedule for lighting and extinguishing street lamps based on the Nautical Almanac.

W. C. M. W.

**278. Improved Street Lighting at Clacton. Anon.**

*El. Times 82, p. 460, October 13th, 1932.*

Particulars and illustrations are given of the installation in Pier Avenue. This consists of centrally suspended units spaced 50 yards apart. Glare has been carefully avoided.

G. S. R.

# The Planning of Gas Installations to Conform with the British Standard Specification for Street Lighting\*

By FREDK. C. SMITH, Assoc. M. Inst. Gas E.

THE object of this paper is to assist the public lighting engineer or other official who may be faced with the task of planning a street-lighting installation to comply with certain specified conditions. In the first place, it is assumed that the installation is required to conform in all respects with the British Standard Specification for Street Lighting (No. 307—1931), issued by the British Standards Institution. The author points out that the present specification assumes a very close relationship between visibility and horizontal illumination on the road surface. It advocates the avoidance of glare and seeks to provide a fairly even illumination over the road surface. There are, however, other factors in regard to visibility which are undoubtedly of importance, and therefore it must not be assumed that schemes based entirely on horizontal illumination are of necessity the best to promote the highest visibility. As he rightly states, "efforts are being made from time to time to revise the specification in order to make it a more equitable basis for tender and to ensure that lighting schemes which result from its application shall promote the highest visibility in the streets." Apart from these remarks, no comment is offered as to the soundness of the requirements included in the specification:

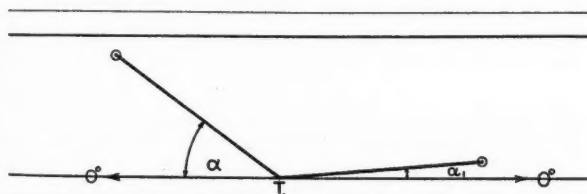


FIG. 1.—Diagram showing angle nomenclature. Staggered formation. Lamps overhung over carriageway.

they are accepted as they stand, and it is only the methods by which they can be satisfied which form the subject-matter of the paper.

The requirements considered are (i) mounting height, (ii) spacing-height ratio (i.e., the distance between neighbouring lamps divided by the mounting height), (iii) test-point illumination, i.e., the illumination measured on a test-plate placed horizontally at road-surface level and at a point midway between adjacent lamps or pairs of lamps, as defined in the specification.

## THE DEVELOPMENT OF A STREET-LIGHTING SCHEME.

The first consideration, at any rate in a new scheme, is the arrangement (or formation) to be adopted for the lights. The author lists the six possible types of regular formation as follows:—

Formation 1. Staggered arrangement, lamps (a) overhung over the road surface, or (b) mounted on columns on the kerb.

Formation 2. Arranged in pairs, overhung over the road surface.

Formation 3. Centrally suspended or mounted on columns in centre of carriageway.

Formation 4. Single-sided lighting, lamps overhung or mounted on columns on kerb.

Formation 5. Alternate pairs and centre lighting or other similar formations.

He considers the special advantages of each formation in turn, and especially recommends Formation 3 as having the following advantages:—

(a) Shadows caused by vehicles across the road surface are shorter than is the case with some other formations.

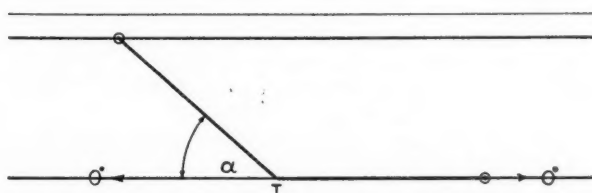


FIG. 2.—Diagram showing angle nomenclature. Staggered formation. Lamps on kerb.

(b) As in the case of Formation 1, the "lane of light" from each lamp falls wholly on the road, and the average brightness is therefore considerably augmented when compared with the staggered system.

(c) This system for a given spacing-height ratio is most economical, in so far as a greater proportion of the flux is utilized on the road surface than with any other system.

In order to limit the size of his paper, the author confines his treatment to Formations 1 (a), 1 (b) and 3. These are shown respectively in Figs. 1, 2 and 3, where the positions of the light-sources are indicated by small circles, and the "test-points" by the letters T and T<sub>1</sub>. The application of the methods described in the paper to other types of lamp formation is sufficiently obvious to make it unnecessary to deal with these in detail.

It is assumed that the following information is supplied to the designer of the installation:—

- (a) The class of illumination to be provided.
- (b) Light-distribution diagrams for various suitable units.

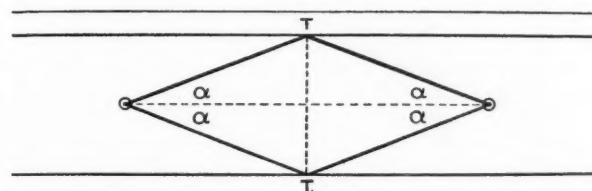


FIG. 3.—Diagram showing angle nomenclature. Central formation.

(c) The dimensions and plan of the roadway, and the arrangement of the light-sources to be adopted.

The designer has to choose the most suitable unit and to decide the height and, for new systems, the spacing at which these units should be mounted. The requirements of the specification as regards the mounting height and the spacing-height ratio suit-

\* Abstract of paper read before the Association of Public Lighting Engineers, at the Ninth Annual Conference, Blackpool, on September 7th, 1932.

able for each class of illumination may be tabulated as follows:—

TABLE I					
Class	Test-point Illm.	Mounting Height		Spacing-height Ratio	
		Min.	Lowest Recommended	Max.	Recommended
A	2.0 f.c. and upwards	30 ft.	30 ft.	5	Not more than 3
B	1.0 f.c.	25 ft.	27.5 ft.	6	" " 4
C	0.5 f.c.	21 ft.	25 ft.	8	" " 5
D	0.2 f.c.	18 ft.	21 ft.	9	" " 6
E	0.1 f.c.	15 ft.	18 ft.	10	" " 7
F	0.05 f.c.	13 ft.	15 ft.	12	" " 8
G	0.02 f.c.	13 ft.	13 ft.	12	" " 10
H	0.01 f.c.	preferably 13 ft.	13 ft.	12	" " 10

The author states that it is usual to consider at least three different mounting heights in order to arrive at the most desirable arrangement. These are normally selected as follows:—

(a) "Minimum" from column 3 of Table II, British Standard Specification for Street Lighting (see Table I above).

(b) "Lowest recommended" from column 4 of the same table, and

(c) Some height greater than (b) by, say, 3 ft.

If, however, practical conditions (such as the height of traffic passing under the lamp) make one or more of these impracticable, it is necessary to replace them in the tentative scheme by one or more stages higher than (c). Whether the "recommended" spacing-height ratio can be realized is very largely a matter of cost. In any case, the

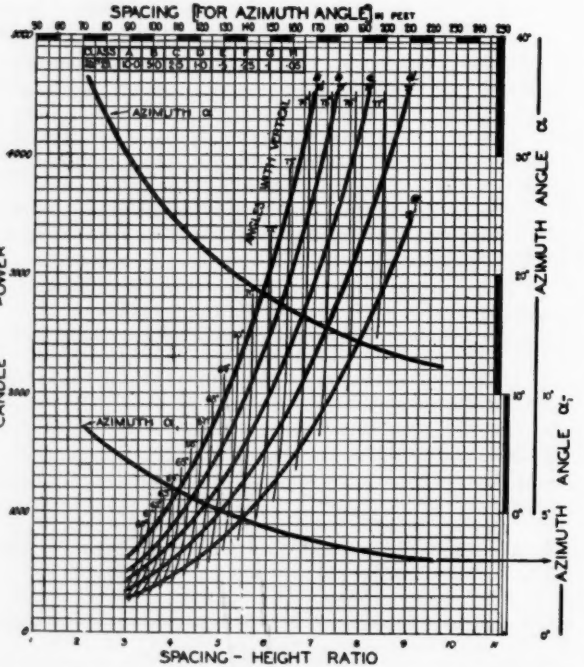


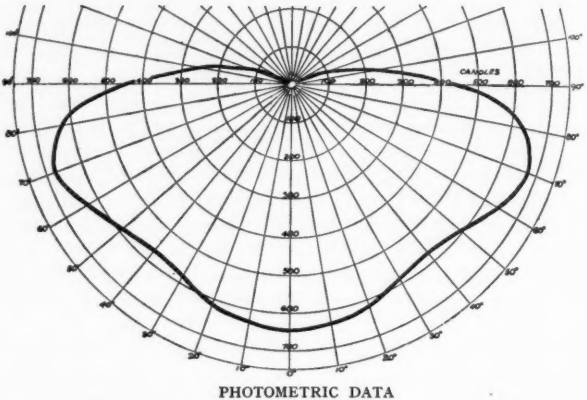
FIG. 4.—Extracted from Appendix (2) for the purpose of illustrating the method of obtaining (a) candle power; (b) vertical angle; (c) azimuth angles.

greater spacings are not practicable when very winding roads are under consideration.

To assist the designer in taking the first step in his calculations, the author gives a set of 13 charts similar to that reproduced in Fig. 4. Eight of these apply to staggered formation, and refer to different breadths of carriageway from 30 ft. to 50 ft., and to

different amounts of overhang from 7 ft. to zero. The remaining five charts apply to central suspension systems for carriageways from 30 to 50 ft. wide. The object of these diagrams is to enable the designer to find at once the candle-power required to produce a given class of illumination with any given arrangement of light-sources.

In the case of a symmetrical type of unit, half the illumination is provided by each of the two nearest units, and the family of five curves in Fig. 4 has been drawn to indicate at once on the scale of ordinates



No. of Unit	Gas Rate in C.Ft. per Hour, 500 B.Th.U. Gas	Candle Power, M.L.H. C.P.	Flux in Lumens		Efficiency		Lumens (Lower Hemisphere) R= Total Lumens
			Lower Hemisphere	Total	M.L.H. Candles Per C.Ft. Per Hour	Total Lumens Per C.Ft. Per Hour	
21	25.0	619	3890	4400	24.8	176	0.88

FIG. 5.—No. 21 Unit.—Distribution Curve. 10.C Mantles, Low Pressure, arranged in cluster and fitted in Suspension Lamp with 30 in. White Enamelled Top Reflector with Lower Half of a Clear Globe frosted and no Directional Reflector.

the candle-power required of each unit to give a Class D illumination with any given spacing-height ratio shown on the scale of abscissæ. Each curve refers to a different mounting height, as follows:—

a 30 ft. d 21 ft.  
b 27 ft. e 18 ft.  
c 24 ft.

The method of using the charts will be made clear by means of an example for which the chart reproduced in Fig. 4 is appropriate. The problem may be stated thus:—

"Required to determine the candle-power necessary to produce Class D illumination from a source mounted 21 ft. high, the spacing-height ratio being 5, width of carriageway 30 ft., units overhung 6 ft., and arranged in staggered formation."

Here curve (d), corresponding to a mounting height of 21 ft. is used, and on this curve the point marked 5 on the scale of spacing-height ratios corresponds to 1,000 on the scale of candle-power. This, then, is the candle-power which must be provided in order to obtain a Class D illumination with this arrangement of symmetrical sources. There is a small table of multiplying factors reproduced on each chart to enable the candle-power required for any class other than D to be obtained at once. Thus, if the class asked for had been E instead of D, the figure of 1,000 would have been multiplied by the factor 0.5 taken from this table, so giving 500 as the candle-power required.

In this way it is possible to calculate the candle-power required from the source. Given a polar-curve of light distribution, such as that shown in Fig. 5, and the angle which the line joining the test-point to the unit makes with the vertical, it is an easy matter to see at once whether the unit to which that polar-curve refers will give the necessary candle-power. The angle can be obtained from the chart

just used for the calculation of candle-power, for it will be seen that there are a number of fine, almost vertical lines crossing the curves of this chart. Curve (d) is intersected very close to the point corre-

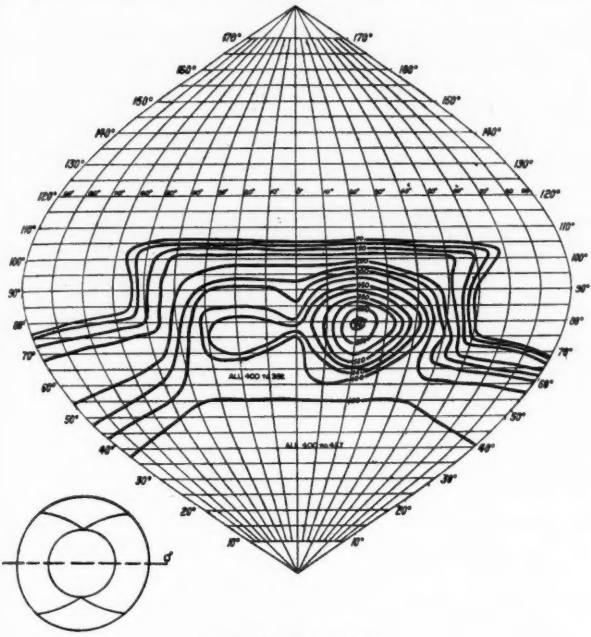
line being the central vertical, while each outer boundary corresponds to 90° of azimuth. The irregular heavy lines pass through all the points representing directions in which the unit has the candle-power\*marked against that line. Thus, in Fig. 6, the candle-power of the unit is 400 in all directions, making an angle of 55° with the downward vertical and lying between azimuth angles of 45° in one direction or 35° in the other. The maximum candle-power is just over 700, and occurs in the direction 80° from the downward vertical and 20° angle of azimuth.

The following description will show how a diagram such as that of Fig. 6 may be employed (in conjunction with a chart of the kind shown in Fig. 4) to determine whether the unit to which the diagram refers will satisfy the conditions laid down.

“Required to produce Class E illumination, given:—

- Width of street, 30 ft.
- Formation—Staggered lamps overhung 6 ft. over carriageway.
- Mounting height—“Lowest recommended,” also lowest practical = 18 ft.
- Unit selected, No. 17. (Fig. 6.)
- Spacing-height ratio — “Maximum permissible = 10.”
- Spacing - height ratio — “Maximum recommended—not more than 7.”

From Fig. 4 determine the following values for



PHOTOMETRIC DATA

No. of Unit	Gas Rate in C.Ft. per Hour, 500 B.Th.U. Gas	Candle Power, M.L.H. C.P.	Flux in Lumens		Efficiency		Lumens (Lower Hemisphere) R = ————— Total Lumens
			Lower Hemisphere	Total	M.L.H. Candles. Per C.Ft. Per Hour	Total Lumens. Per C.Ft. Per Hour	
17	12.5	363	2278	2525	29.0	202	0.9

FIG. 6.—No. 17 Unit.—Distributive Curve. 5.C Mantles, Low Pressure, arranged in cluster and fitted in Suspension Lamp with 22in. White Enamelled Top Reflector with Clear Globe and one 3-tier and one 2-tier Staybrite Steel Directional Reflectors.

sponding to spacing-height ratio 5 by a vertical line marked 69°. Actually a closer approximation (obtained by estimated interpolation between the 69° and 70° lines) gives the value 69.2° as the angle required. The polar curve of Fig. 5 shows that at this angle the unit gives a candle-power of about 670. It would therefore provide an illumination rather above that required for Class E, but not enough for Class D.

For sources with an asymmetrical distribution a somewhat different procedure must, clearly, be followed. In the first place, it is necessary to take into account the angle on plan (or angle of azimuth) of the unit as viewed from the test-point. These azimuth angles are marked  $\alpha$  and  $\alpha_1$  in Figs. 1 to 3. For any given arrangement of units covered by the thirteen charts similar to Fig. 4 the angles  $\alpha$  and  $\alpha_1$  may be obtained at once from the two curves marked “azimuth  $\alpha$ ” and “azimuth  $\alpha_1$ .” It will be seen by reference to Fig. 4 that for a spacing of 105 ft. (corresponding to a mounting height of 21 ft. and a spacing-height ratio of 5) the angle  $\alpha$  is 26° and  $\alpha_1$  is 6°. (It is to be noted that for lamps mounted vertically above the kerb  $\alpha_1$  is always zero.)

Next the candle-power in the direction of the test-point must be found for each of the two nearest units. Since these units do not give a symmetrical distribution, the ordinary polar-curve is no longer of any use, and it must be replaced by a diagram showing the candle-power of the unit in any direction in space. Such a diagram, termed an iso-candle diagram, is reproduced in Fig. 6. In this diagram angles from the downward vertical are marked against the horizontal straight lines, while angles of azimuth are marked against the curved lines, the zero

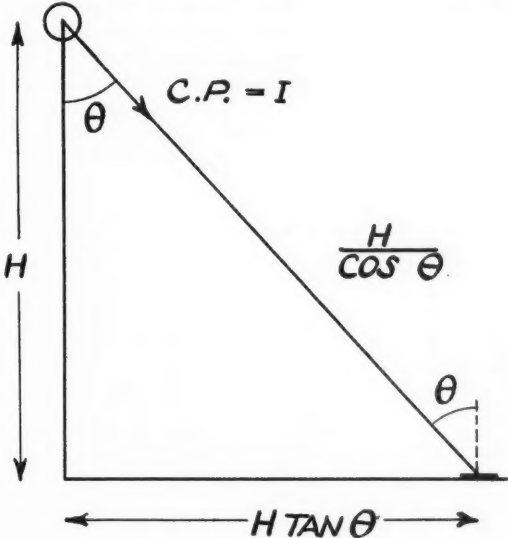


FIG. 7.—Cosine-cubed law.

E = (I cos θ) / (H / cos θ)² = I cos³ θ / H²

spacing-height ratios 5, 5½, 6, 6½ and 7, and tabulate figures as follows:—

TABLE II—TABULATION OF DATA FROM FIG. 4

Spacing Height Ratio	Candle Power Required			Vertical Angle θ	Azimuth Angles	
	Curve Reading for Class D	Factor	Total C.P. Required for Class E		α	α₁
(1)	(2)	(3)	(4)	(5)	(6)	(7)
5	780	2 × 0.5	780	69½°	30°	7½°
5½	950	2 × 0.5	950	71½°	27°	6½°
6	1,180	2 × 0.5	1,180	72½°	25°	6°
6½	1,430	2 × 0.5	1,430	73½°	22°	5½°
7	1,730	2 × 0.5	1,730	74½°	21½°	5½°

Referring to distribution curve for Unit No. 17 (Fig. 6), the following table may now be completed:

TABLE III—TABULATION OF DATA FROM FIGS. 4 & 6  
Columns 1, 2 and 3 from Table II.  
Columns 4, 5 and 6 from Fig. 6.

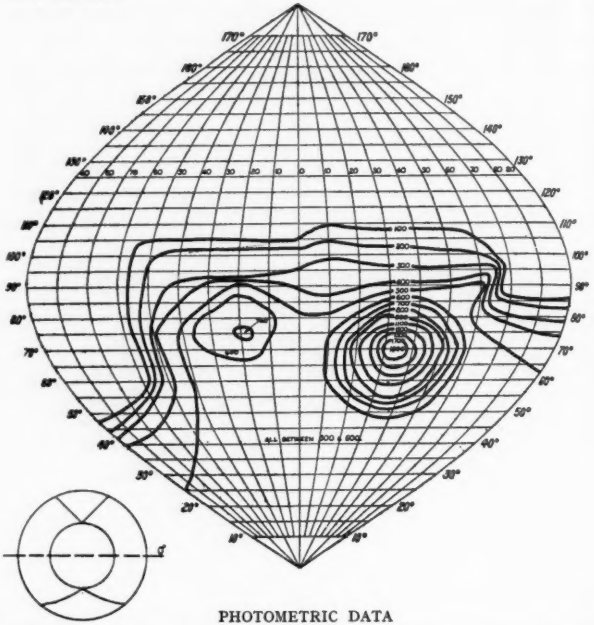
Vertical Angle $\theta$	Azimuth Angles		Candle Power at Vertical Angle $\theta$ and Azimuth Angle $\alpha$	Candle Power at Vertical Angle $\theta$ and Azimuth Angle $\alpha_1$	Total C.P. from Unit in Required Direction
	$\alpha$	$\alpha_1$			
(1)	(2)	(3)	(4)	(5)	(6)
69½°	30°	7½°	510	380	890
71½°	27°	6½°	560	390	950
72½°	25°	6°	600	380	980
73½°	22°	5½°	625	380	1,025
74½°	21½°	5½°	650	460	1,110

Comparing these two tables, it is evident that with a mounting height of 18 ft., and spacing-height ratio of 5½, the requirements for Class E can be satisfied. In a similar manner any other scheme may be developed. It should be noted, however, that if more than two sources are contributing to the test-point a slight modification in this method is essential.

THE DEVELOPMENT OF ISO-LUX DIAGRAMS.

In order to obtain some idea of the distribution of illumination over the roadway for any given system of street lighting it is often desired to construct the iso-lux diagram for a unit of the lamp formation adopted. This diagram is a "contour-diagram" of the roadway, in which the "contour" lines represent lines of equal illumination. The construction of such a diagram is a fairly simple matter if only two sources of light are contributing to the illumination at the test-point, especially if the light-sources have a symmetrical distribution about a

axis is not symmetrical. The latter condition has nearly always to be faced when directional reflectors are in use.



No. of Unit	Gas Rate in C.Ft. per Hour, 500 B.Th.U. Gas	Candle Power, M.L.H. C.P.	Flux in Lumens		Efficiency		Lumens (Lower Hemisphere) R = Total Lumens
			Lower Hemisphere	Total	M.L.H. Candles Per C.Ft. Per Hour	Total Lumens Per C.Ft. Per Hour	
19	17.5	544	3415	3750	31.1	215	0.91

FIG. 9.—No. 19 Unit.—Distribution Curve. 7.C Mantles, Low Pressure, arranged in cluster and fitted in Suspension Lamp with 30 in. White Enamelled Top Reflector and one 3-tier and one 1-tier Mirror Glass Directional Reflectors.

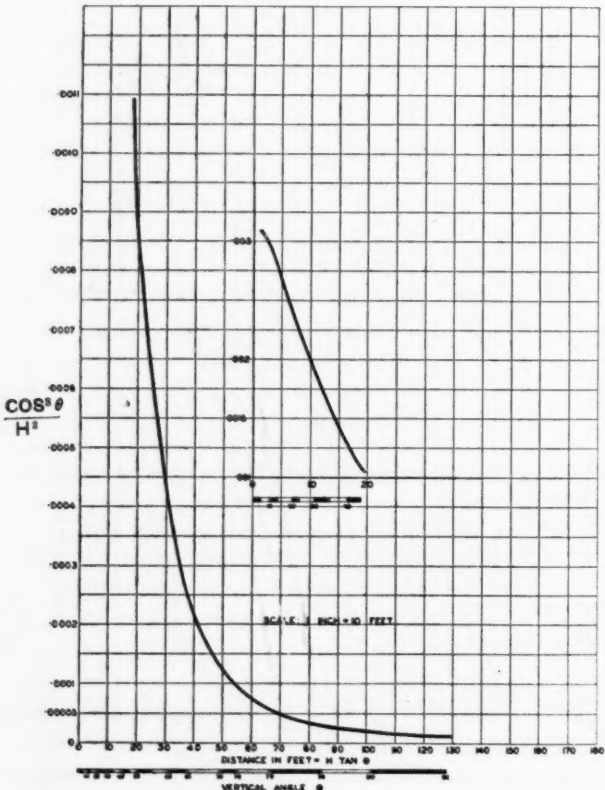


FIG. 8.—Illumination curve for source of unit candle-power. (H = 18 ft.)

vertical axis. It is somewhat complicated and tedious, however, if the illumination is contributed by more than two sources of light, and is especially complicated if the distribution about the vertical

The first step is to construct an illumination curve for a source of unit candle-power using the "cosine-cubed" formula  $E = (I \cos^3 \theta) / H^2$ , where E is the illumination at a given point, H is the mounting height,  $\theta$  is the angle which the line from the source to the point makes with the downward vertical, and I is the candle-power of the source in the direction  $\theta$  (see Fig. 7). In the case of the unit candle-power curve  $I = 1$  for all values of  $\theta$ . It is convenient to plot the curve so that the scale of abscissæ represents distances from the base of the lamp column, i.e.,  $H \tan \theta$ . Such a curve is shown in Fig. 8 for a mounting height  $H = 18$  ft.

The next step is to take a web such as that used for plotting polar diagrams, and let this represent the ground immediately surrounding the base of the column. The unit is supposed to be suspended at a height H vertically above the centre-point of the web. Distances along the radial lines represent distances from the column (to any convenient scale) while the angles marked on the radial lines represent angles of azimuth.

For example, take the iso-candle diagram shown in Fig. 9. From Fig. 8 it will be seen that at a distance of 30 ft. from the base of the column the angle  $\theta = 59^\circ$  and the illumination due to unit candle-power is 0.00043. From Fig. 9 the candle-power at  $59^\circ$  from the vertical and  $0^\circ$  angle of azimuth is nearly 600 (say 580), so that the actual illumination 30 ft. from the column is  $580 \times 0.00043 = 0.25$  foot-candles. Taking a scale of 10 ft. per division on the radial lines, this means that one point on the 0.25 line of the iso-lux diagram lies on the third circle from the centre of the web where this crosses the radial line marked  $0^\circ$ . Similarly, the illumination at a distance of 30 ft. and  $40^\circ$  angle of azimuth (where the candle-power at  $59^\circ$  from the vertical is shown by Fig. 9 to be 1,100) equals  $1,100 \times 0.00043$

= 0.47 foot-candles. Thus the 0.5 line of the iso-lux diagram crosses the radial line marked 40° on the web just inside the third circle. In this way the whole of the iso-lux diagram shown in Fig. 10 can be plotted point by point.

To obtain the complete iso-lux diagram for a unit of the lamp formation it is necessary to place a

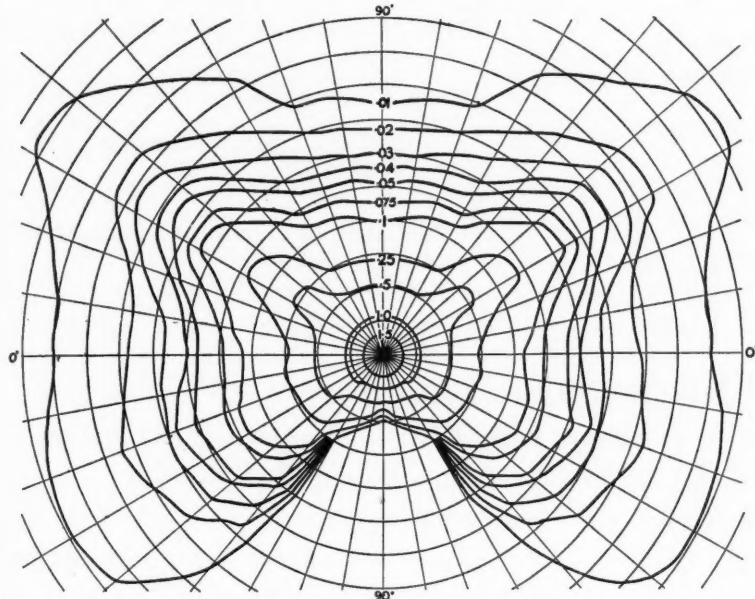


FIG. 10.—Iso-lux for single unit developed on web.

“single-source” diagram with its centre at the position (on plan) of each of two adjacent lamps, as shown in Fig. 11. Adding the illuminations due to the two sources, as given by the two diagrams, it is clearly an easy matter to obtain the final iso-lux

Class 1. In this class the directing surface is fitted underneath the mantles in order to re-direct some of the downward flux, which would normally illuminate the surface around the base of the column, into a zone suited to street-lighting requirements.

Class 2. Reflectors designed to re-direct the flux, which would normally fall on the houses, on to the road surface.

Class 3. Reflectors designed to re-direct on to the road surface the flux which would normally pass into the upper hemisphere.

Up to the present the great majority of directional reflectors used have been made of Staybrite steel, or chromium-plated copper, but recently mirror-glass with an electrically deposited lead coating at the back of the mirror, in order to preserve the mirror from damage, has become available, and there is reason to believe that this coating will effectively prevent weather conditions from destroying the reflecting surface.

#### DATA ON STREET-LIGHTING UNITS.

Appendix (1) of the paper gives very full details of the characteristics of twenty-five street lighting units. In addition to descriptions of the units, full details of their performance are given, including an iso-candle diagram for each (except four which are symmetrical and for which the polar curve is shown). Figs. 5, 6 and 9 are taken from this appendix.

Appendix (2) contains the 13 charts similar to Fig. 4, while, in an extensive series of tables,

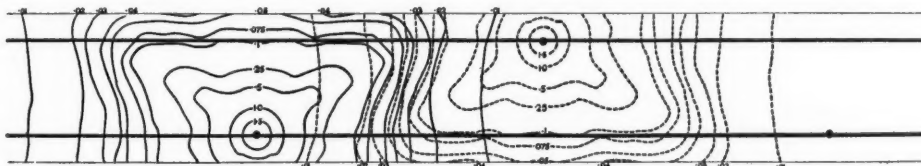


FIG. 11.—Road plan with Iso-lux for each unit superimposed.

diagram required (see Fig. 12). It will be seen that the preparation of such a diagram is somewhat laborious. Another method is to select a number of points on the road surfaces at positions agreed upon

Appendix (3) contains summaries of over 200 lighting schemes for Classes C to H of the Standard Specification. In each case the mounting-height, spacing, particular unit employed, gas consumption

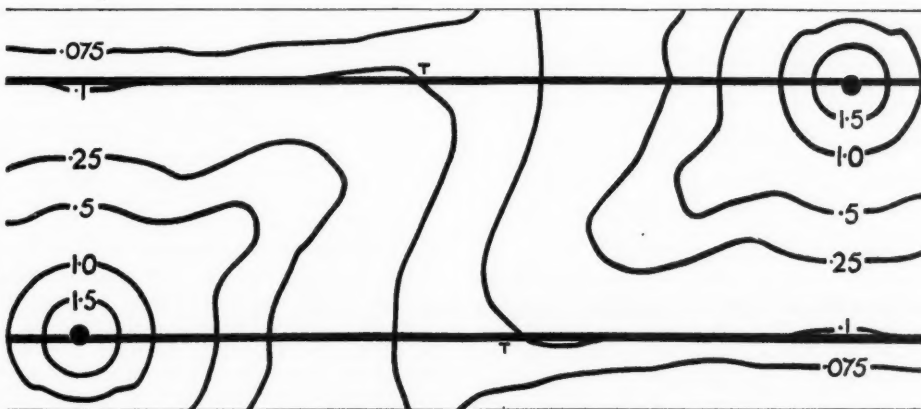


FIG. 12.—Completed Iso-lux diagram.

between the contracting parties, and calculate the illumination at these points.

The paper concludes with a section on directional reflectors for gas units. The author classifies such reflectors as follows:—

and gas used per 1,000 square feet of roadway per hour are given. Finally, some details of the demonstration lighting in Whitehall during September, 1931, are included.

Appendix (4) contains some recommendations for

the assignment of the classes in the Standard Specification to roads of different types as follows:—

- Class B—
  1. Important central thoroughfares in large cities.
  2. Important central traffic crossings and circuses in large cities.
- Class C—
  3. Main roads in central areas of large cities.
  4. Important commercial thoroughfares in central areas of large cities.
  5. Important central thoroughfares of smaller towns.
  6. Important central traffic crossings and circuses in smaller towns.
- Class D—
  7. Important commercial thoroughfares (not in central areas) of large cities.

8. Important commercial thoroughfares in smaller towns.
- Class E—
  9. Shopping areas in small towns and suburbs of large cities.
  10. Secondary traffic routes in large towns.
- Class F—
  11. Main suburban roads with through traffic.
- Class G—
  12. Residential thoroughfares with through traffic.
  13. Side streets and squares in central areas of large towns.
- Class H—
  14. Residential roads in suburbs of large towns with no through traffic.
  15. Side streets in small towns.

Modern Electric Street Lighting—  
The Planning of Installations to Conform with British Standard Specification  
No. 307-1931, with Special Reference to the Iso-candle Diagram \*

By G. H. WILSON, B.Sc. (Eng.), A.M.I.E.E.

IN planning an installation to conform with the specification, the first point to be decided is the class of installation needed, and this depends on the size and importance of the thoroughfare and upon the amount of traffic carried by it. A suggested guide on this matter has been prepared by Jones and Davies, and is given in the following table:—

TABLE I.  
*Recommendations for the British Standard Class of Street Lighting Installations for Streets of various kinds.  
(Suggested by Jones and Davies).*

Street	Lowest Class Recommended
Important central thoroughfares in large cities. (Spectacular lighting.)	Class B.
Important central traffic crossings, circuses, etc.	
Main roads in central areas and large cities. Important commercial thoroughfares in central areas of large cities.	Class C.
Important central thoroughfares of smaller towns.	
Important commercial thoroughfares not in central areas of large cities. Important commercial centres in smaller towns.	Class D.
Shopping areas in small towns and suburbs.	
Main suburban roads with through-traffic.	Class F.
Residential thoroughfares with through-traffic.	Class G.
Residential roads with no through-traffic.	Class H.

ARRANGEMENT OF UNITS.

The lighting units can be arranged in a variety of ways, and of these the five most commonly adopted are shown in Fig. 1. (The various dimensions to be referred to later in this paper are shown more clearly in Fig. 2.) The relative advantages of the various arrangements have been summarized by Waldram as follows:—

- (a) Single side (IV):—

Liabile to be bad on polished or wet roads.  
Visibility is particularly liable to be poor on

- polished or wet roads if the units are not mounted on the outside of curves.
- (b) Central (III):—

Usually better than (a), but liable to be bad on polished or wet roads, and particularly on curves, unless the units are on the outside of curve.
- (c) Staggered (I):—

Has not the disadvantages of (a) and (b) on polished or wet roads or on curves. Can be good.
- (d) Double side (II):—

Generally good.

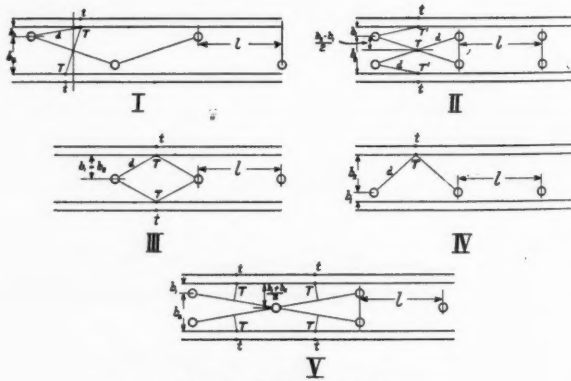


FIG. 1.—Units of System.

A further point which needs consideration in all arrangements but central suspension is the overhang of the units over the carriageway. On account of the reflection characteristics of the majority of road surfaces, the regions of higher road brightness are usually between the observer and the lighting units, in the neighbourhood of the lines which join the observer to points underneath the units. If these regions are too limited in area, poor visibility may result, and the comments on the systems made in the above schedule are based on the probability of this occurring.

On account of possible increases in traffic and in the importance of thoroughfares, installations should be planned with a view to a possible improve-

\* Abstract of paper read before the Association of Public Lighting Engineers at Blackpool, September 7th, 1932.

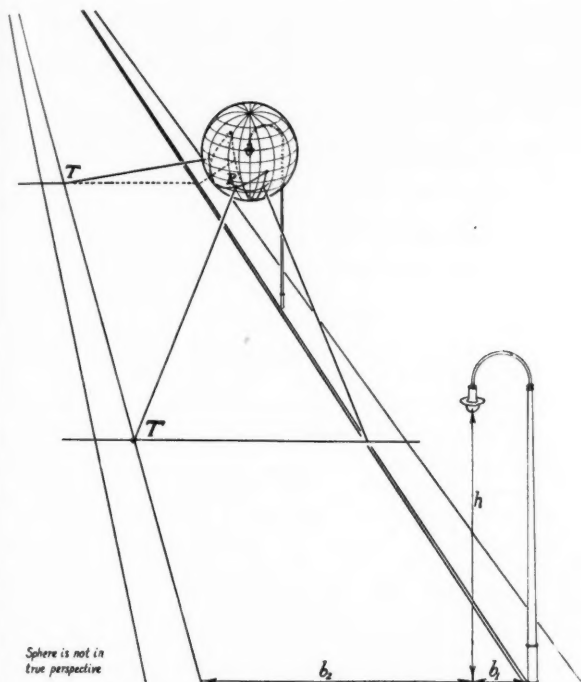


FIG. 2.—Perspective Sketch of Single-side Installation.

ment in the class. In view of this it is always advisable to arrange that the mounting-height and spacing-height ratio are suitable for a higher class than the one for which the immediate design is being prepared.

#### TYPE OF LIGHT DISTRIBUTION.

The bare incandescent electric lamp distributes its light almost uniformly in all directions from the downward vertical to about  $50^\circ$  or  $60^\circ$  above the horizontal. By means of reflectors, refractors and diffusers light can be re-directed so that it is diverted from directions of less importance. The fittings in use at the present time may be grouped in three main classes as follows:—

- (a) The uncontrolled or partially controlled distribution.
- (b) The controlled symmetric distribution.
- (c) The controlled asymmetric distribution having as sub-classes:—
  - (i) Two-way axial.
  - (ii) Two-way non-axial.
  - (iii) Three-way.
  - (iv) Four-way.

Class (a) includes bare lamps and fittings with small over-reflectors which collect and reflect but little light. Decorative units having diffusing glass

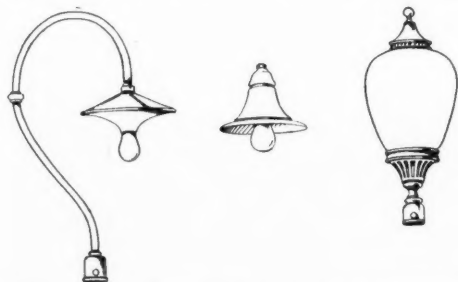


FIG. 3.—Examples of Units having Uncontrolled or Partially-controlled Distributions.

and no re-directive equipment will also come under this heading. Three typical units in Class (a) are shown in Fig. 3.

Class (b) includes those units which by reason of specially shaped reflecting or refracting surfaces

produce a marked concentration of light equally all round the unit at angles between  $60^\circ$  and  $80^\circ$  to the vertical. Fig. 4 shows four types of such units.

The symmetric units in Class (c) do not concentrate equally all round the unit, but in preferred



FIG. 4.—Examples of Units having Controlled Symmetric Distributions.

directions, so that a high proportion of the light from the lamp is directed on to the roadway. The light may be concentrated into two main beams which are in opposite directions (axial) or in



FIG. 5.—Examples of Units having Controlled Asymmetric Distributions.

directions having an angle of, for example,  $160^\circ$  or  $140^\circ$  between them (non-axial). It is also possible to direct the light into three or four beams, so that at road intersections or crossings high utilization may be obtained (three or four-way). Types of asymmetric unit are illustrated in Fig. 5.

In general, symmetric units are suited to the wider roads and shorter spacings and asymmetric units to narrower roads and longer spacings, but asymmetric

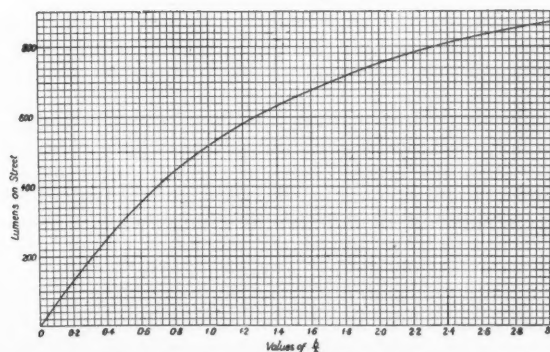
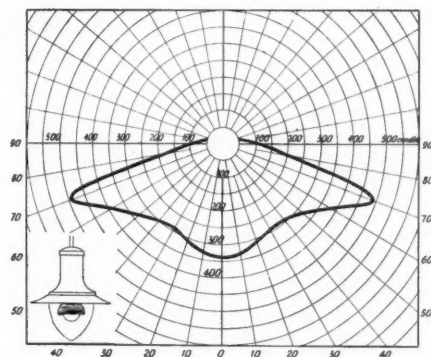


FIG. 6.—Symmetric Dome Refractor. 200-watt lamp, 2,660 lumens. Add 5 per cent. if no globe is used.

units with a relatively slight asymmetric effect are now frequently used on the shorter spacings.

One obvious method of deciding which unit to use is to determine by the method shortly to be described the test-point illuminations given by various units, and to choose the one which gives the highest test-point value, whilst also possessing such other features of distribution as may be required in connection with the illumination of buildings and the like. But in making a choice on such a basis it should be remembered that if in a given installation the test-point illumination is raised by extreme asymmetry of the light distribution, glare will inevitably tend to increase. This, if carried to an extreme, will be contrary to the instruction of the specification, which says that the installation should be as free as practicable from glare.

The light distribution from uncontrolled or controlled symmetric units can be exhibited in the form of a simple polar curve. In the case of asymmetric units a series of curves is required or an iso-candle diagram such as that shown in Fig. 7.

#### THE CHOICE OF A TYPE OF LANTERN.

In choosing a particular design of lantern regard must be had to details of mechanical construction. Bound up with this is the extremely important matter of maintenance. Simple units with little or no re-directive equipment can be made easy to clean, and usually of a form which does not encourage dirt collection. Units with re-directing reflectors or refractors cannot always be made so simple to maintain nor so free from the disadvantages of dirt collection. They must be rigidly constructed so that the lamp and reflector or refractor are maintained in their correct relative positions, and they must be erected carefully so that the re-directed light is concentrated in the correct directions.

Surfaces which are nearly horizontal will usually collect less dirt on their under-sides than on their upper-sides, and so units whose active reflecting or refracting surfaces are facing downwards will tend to become less dirty than those which face the other way.

There are those who contend that any advantages which accrue from the use of re-directive equipment are more than offset by the disadvantages of extra maintenance. This is not necessarily so. Firstly, all re-directive equipment is not liable to excessive dirt collection. In some designs of unit, the deposition is probably no greater than with a simple inverted cone reflector. Secondly, in places where a short regular cleaning period is employed any units can be kept near their maximum efficiency with comparative ease. Where it is desired to have long cleaning periods, and yet have high efficiency units, precautions can be taken against depreciation and equipment of suitable type is available. For example, refractor fittings can be obtained in which the prismatic elements are in two parts so that the prism surfaces are enclosed and the refractors have

smooth exteriors, and others are available in which a one-piece refractor is used, but it is enclosed in an outer glass for the purpose of reducing dirt depositions.

The choice of type will depend on the atmospheric conditions of the locality and on the maintenance schedule which it is proposed to adopt.

#### SELECTION OF THE ACTUAL UNIT.

It is presumed that the following have been decided:—

- (i) Class of installation.
- (ii) Unit of system, height ( $h$ ), spacing ( $l$ ) and offset ( $b_1$ ).
- (iii) Type of light distribution.
- (iv) Type of lantern.

It now remains to choose a lantern such that the test-point illumination will be not less than that specified for the class selected.

This involves a knowledge of the performance of the available units, and the data relating to 24 units (14 symmetric and 10 asymmetric) are given in Appendix III of the paper. Two typical diagrams taken from this appendix are shown in Figs. 6 and 7. There are two steps in this stage of the work, viz.:—

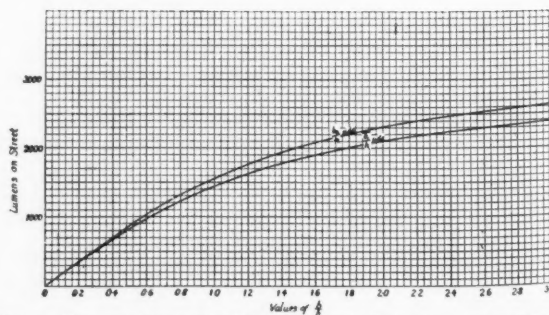
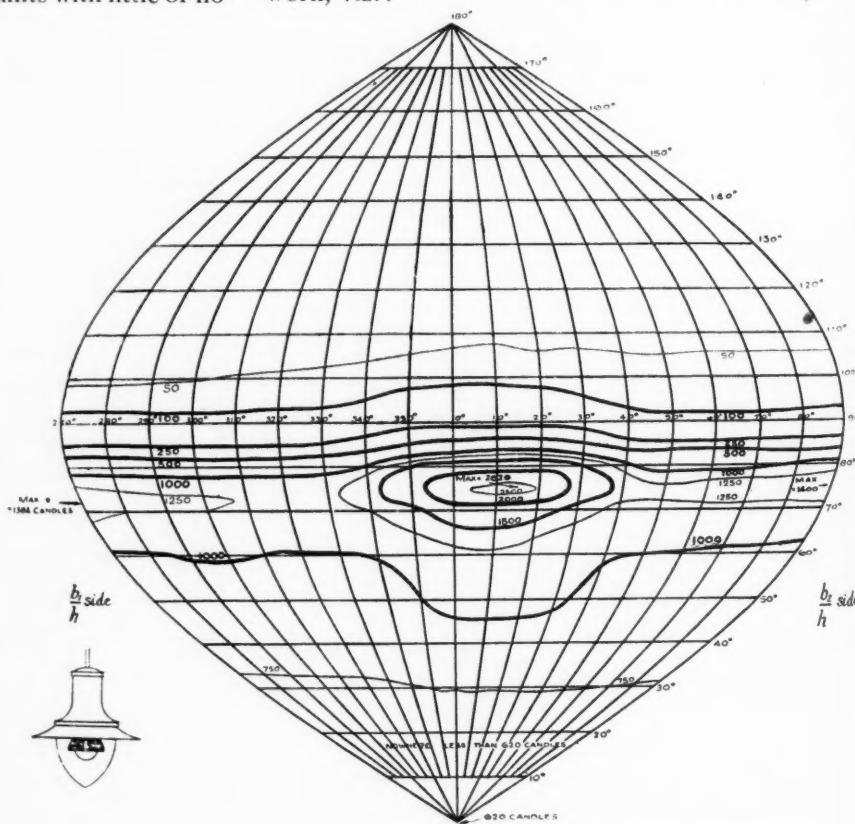


FIG. 7.—Two-way Non-axial 160° Asymmetric Refractor. 500-watt lamp. 7,700 lumens. Add 5 per cent. if no globe is used.

- (a) Finding the direction of the test-point as seen from the lighting units in the span.
- (b) Calculating the candle-power required to provide the test-point illumination called for by the class decided upon.

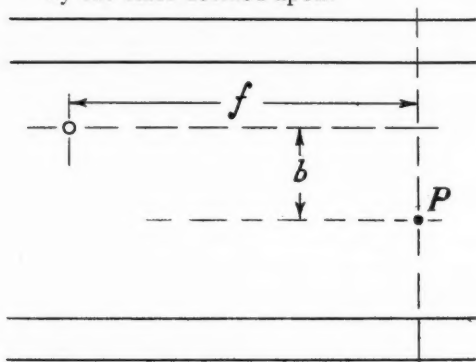


FIG. 8.—Plan of Installation with one Unit and one Test-point.

The first stage may be described by reference to Fig. 8, in which P is the point whose direction from the unit it is required to find. P is somewhere on any line parallel with the street which is at a distance  $b$  from the unit, and also somewhere in a line at right angles across the street which is at a distance  $f$  from the unit. These two lines can be represented on the web used for the iso-candle diagrams, it being noted that the position of the lines will not depend on the actual distances  $b$  and  $f$ , but on the ratios  $b/h$  and  $f/h$ , where  $h$  is the mounting height. In Fig. 9

correction to this distance has to be applied, and methods of finding this correction either graphically or by calculation are described in the paper.

Once  $b/h$  and  $f/h$  have been calculated for the test-point, the direction of this point as seen from the unit can be marked on the web, and hence the angle  $\theta$  which this direction makes with the downward vertical can be read from the  $\theta$  scale (i.e., the scale marked on the equidistant horizontal lines on the web). This done, the total candle-power required to give the test-point illumination can be found from the familiar formula

$$I = \frac{Eh^2}{\cos^3 \theta}$$

where  $I$  is the required candle-power,  $E$  is the test-point illumination, and  $h$  is the mounting height (in feet if  $E$  is expressed in foot-candles). Appendix III of the paper contains a table of values of  $\cos^3 \theta$  and a chart which gives, for all values of  $h$  and  $\theta$  the value of  $I$  needed to obtain any one of the eight classes of street illumination included in the specification.

Once  $I$  has been calculated, the particular unit which will give the requisite candle-power can easily be found. In the case of units for which an iso-candle diagram is available it is only necessary to transfer the point of intersection of the  $b/h$  and  $f/h$  lines to any of the iso-candle diagrams, and to read off the intensity at once or, in the case of polar curves, to read off immediately the intensity at the angle  $\theta$ . If the total intensity in the direction of the test-point, from all the sources of the type under consideration, in one span, is greater than the required candle-power, then the class desired will be obtained.

Having derived the constants for the calculation of the test-point illumination in the carriageway, it is a simple matter to determine the test-point illumination in the foot-way. The method of doing this is described in the paper.

#### EXAMPLE.

The following example will illustrate the process which has been described above:—

Street — important commercial centre in small town.

Width of carriageway—30 ft.

Recommended minimum class—D.

Test-point illumination — 0.2 foot-candles.

Unit of system—Staggered (I).  
Height—21 ft.

Spacing-height ratio—Not more than six recommended: Spacing of 120 ft. adopted, giving spacing-height ratio  $r = 5.7$ .

Overhang  $b_1$ —5 ft.

Type of distribution—Asymmetric two-way non-axial.

$b_2 =$  street width less  $b_1 = 25$  ft.

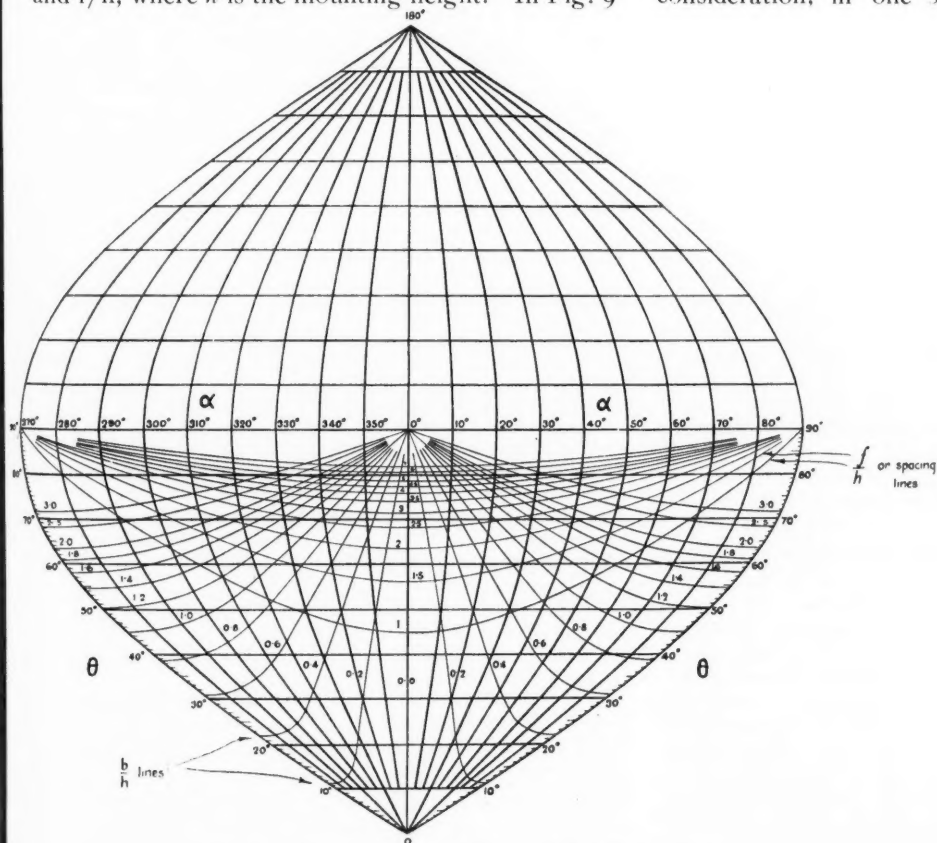


FIG. 9.—Sinusoidal Web with  $b/h$  Lines and  $f/h$  or Spacing Lines.

lines corresponding to various values of  $b/h$  on both sides of the unit and also a set of  $f/h$  lines have been drawn.

In the case of systems II, III and IV of the British Standard Specification (see Fig. 1) the distance  $f$  corresponding to the test-point is equal to half the spacing, so that  $f/h$  is equal to half the spacing-height ratio  $r$ . For the other two systems a small

Here  $b_1/h = 5/21 = 0.24$ .  
 $b_2/h = 25/21 = 1.2$ .

The correction to the spacing-height ratio, due to the fact that the staggered system is employed, is found from the chart in Appendix III to be 0.12. Thus the spacing line to be used on the  $b_1$  side is  $\frac{1}{2}r + 0.12 = 2.97$ , and that on the  $b_2$  side is  $\frac{1}{2}r - 0.12 = 2.73$ .

Referring now to Fig. 9, and estimating the position of the  $\frac{b_1}{h}$  curve for 0.24 and the spacing-line for 2.97, a point can be determined. Its angle to the vertical  $\theta$  will be found to be  $71.5^\circ$ .

Taking the  $\frac{b_2}{h}$  curve for 1.2, and estimating the position of the spacing-line for 2.73, a second point can be found. Its angle must also be  $71.5^\circ$ , but it is further from the centre line of the diagram than the first point. These two points will be used for finding the candle-power from the iso-candle diagrams.

The value of  $\theta = 71.5^\circ$  and that of  $h = 21$  ft. enable I to be evaluated as follows:—

$$I = \frac{E \times h^2}{\cos^3 \theta} = \frac{0.2 \times (21)^2}{\cos^3 71.5^\circ} = 2,670 \text{ candles.}$$

Any of the non-axial asymmetric performance curves can now be referred to and the intensity read off from the curves for the points already determined. The diagram in Fig. 7 gives values of 1,750 and 1,750, and the sum of these two is 3,500, so that if these units are selected the installation will comply with the specification for a Class D street.

The additional calculations necessary to determine the footway test-point illumination are given in full in the paper.

CALCULATION OF AVERAGE ILLUMINATION.

In connection with information to be supplied with a tender (Clause 23) average illumination is called for, and the iso-candle diagram provides a ready method of determining this quantity. The method is described briefly with an example in the specification, but the following is a more complete treatment.

The sinusoidal web type of iso-candle diagram has the feature that the luminous flux in any zone, such as that bounded by two iso-candle lines, may be determined by the product of the area of the zone on the diagram to any scale, the average intensity of the unit over the zone and a constant  $\frac{2\pi}{A}$ , where A is the area of the complete diagram to the same scale.

In order to find the amount of luminous flux from a lighting unit which reaches the road in an installation, it is only necessary to perform the above calculation for zones on the iso-candle diagram bounded on the upper side by the two  $b/h$  lines which represent the kerbs or road boundaries, and on the lower side by the edge of the diagram. The result will be the total flux from one side of the unit (the iso-candle diagram portrays only one side) falling on the street, assuming it is long and straight. To allow for the other side of the unit the result so obtained should be doubled, and this gives the total light from the unit falling on a long street.

When a complete installation is being considered the average illumination will be obtained by dividing the total flux from all the units falling on the road by the road-surface area. It can be shown that the same result is obtained in a simpler manner by dividing the total light reaching the road from the number of units in one span by the span area.

Table II gives the number of units per span for units of system given in the specification, and also

the length of span in terms of the length l in Fig. 1. This length, multiplied by the road width, gives the span area.

TABLE II.

Unit of System		Number of units per span	Length of span
No.	Description		
I.	Staggered .. .. .	1	1
II.	Double-side .. .. .	2	1
III.	Central .. .. .	1	1
IV.	Single-side .. .. .	1	1
V.	Double-side-central .. .. .	3	21

There is a small error if the installation is short, but this can safely be neglected in cases of more than one span in length.

The accuracy of the results will depend on the closeness of the intervals at which the contours on the iso-candle diagram have been drawn. To ensure that a reasonable accuracy is obtained, it is suggested in the specification that when determining the flux in various zones the area between contours should be multiplied first by the intensity value of the upper contour and then by the value of the lower contour, and the mean of the sums of the two sets of values so found should be used, provided that the two sums do not differ by more than 20 per cent. from the mean. If this is not the case more contours are required on the iso-candle diagram. An example showing how to employ this method is given in the specification.

Should it be desired to obtain the average illumination of an installation of only one span, the zones of the iso-candle diagram used for the calculation will be bounded by the appropriate  $b/h$  lines, the lower edge of the diagram and, at the top, a spacing-line of  $f/h$  value equal to  $1/h$ , where l is the length of span.

To avoid the necessity for the designer making a long calculation for every installation, this has already been done for those iso-candle diagrams in Appendix III, and curves on the lines suggested on page 24 of the specification have been prepared. These curves connect, for every unit, the total flux between the vertical and a  $b/h$  line for both sides of the unit with the value of  $b/h$ . In order to determine the average illumination in any installation it is only necessary to find from the curves the lumens

appropriate to the values of  $\frac{b_1}{h}$  and  $\frac{b_2}{h}$ , to add these together, and to divide the sum by the area of the span. Taking the example which has already been worked out for the Class D installation, the following values are found:—

From the curves for the total lumens on street in Fig. 7 it is seen that the total lumens corresponding to the values  $\frac{b_1}{h} = 0.24$  and  $\frac{b_2}{h} = 1.2$ , are 400 and 1,764, totalling 2,164. The installation is staggered, therefore from Table II there is one unit per span, and the length of the span taken should be  $l = 120$  ft. The area is therefore 120 ft. by 30 ft., and the average illumination is  $\frac{2,164}{120 \times 30} = 0.6$  foot-candles.

Curves for the total lumens falling on the street for uncontrolled or symmetric units can be calculated from iso-candle diagrams drawn for the units. In such diagrams the iso-candle lines are horizontal straight lines, and the determination of the areas between the various contours and the  $b/h$  lines is a relatively simple matter.

ISO-FOOT-CANDLE DIAGRAMS.

Some designers prefer to plan their installations

from iso-foot-candle rather than iso-candle diagrams.

If it is desired to have a complete plot of the illumination in a span after the installation has been calculated from an iso-candle diagram there are several methods available. One method is to plot out on a plan of the street radial lines and concentric circles corresponding to the lines of latitude and longitude on the web. These will radiate from a point on the plan directly underneath a fitting. To the scale of the diagram the distance of each of the concentric circles from the point under the fitting will be equal to  $h \tan \theta$ , where  $h$  is the mounting-height and  $\theta$  is the vertical angle of the line of latitude on the web. For any point on the iso-candle diagram a corresponding point can be found on the plan of the street and the illumination at this point can be found from the equation

$$E = \frac{I \times \cos^3 \theta}{h^2}$$

By estimating the position of points of equal illumination an iso-foot-candle diagram can be produced, and by superposition the diagram for a complete installation can be prepared.

One other method is to draw on a plan of the road a grid of squares or rectangles, and to transfer the corners of the grid to corresponding points on the iso-candle diagram. The intensity of the unit at these points can be read off the diagram, and from the equation just given the illumination on the road can be calculated if  $\theta$  is read from the web. If the size of the grid is carefully chosen with respect to the size of the span and the position of the units, when the diagram is reversed and superposed, the corners of the rectangles will be over one another, and it is a simple task to make the addition. The position of iso-foot-candle curves can then be estimated from the foot-candle values at the corners of the rectangles.

#### APPENDICES.

Three appendices to the paper give respectively:

- (i) A full description of the method of construction of the iso-candle diagram.
- (ii) Certain calculating charts by means of which test-point illuminations may be found.
- (iii) Performance diagrams of representative units (like those reproduced in Figs. 6 and 7).

#### DISCUSSION

Lt.-Commander HAYDN T. HARRISON congratulated the authors of both papers. Evidently intricate calculations would be necessary to cover the whole of the lighting conditions in a street. The processes described necessarily dealt with only a part. He congratulated Mr. Smith on the explanation of the "onion" diagram. Ten years ago the conception of iso-candle diagrams was quite unfamiliar. Even to-day they were not widely understood, so that the explanation was very opportune. He recalled Mr. Trotter's early work on iso-lux diagrams, which he thought easier to understand and not really difficult to prepare when one was concerned with a definite area. He wished that some understanding could be arrived at in regard to the specification of the light-giving value of street lamps, e.g., whether in terms of mean spherical or mean hemispherical candle-power. He wished to emphasize the great importance of adequate illumination in a vertical plane, on which the recognition of people and objects mainly depended.

Mr. L. T. MINCHIN briefly explained the application of the diagram to the determination of illumina-

tion on the vertical face of buildings. He also exhibited a slide illustrating unequal illumination and the formation of bright patches on the roadway, which rendered very careful surveying of the area illuminated necessary. The iso-candle was specially useful in enabling such cases to be investigated.

Mr. E. STROUD congratulated both Mr. Smith and Mr. Wilson on their excellent work. The papers both exemplified the unbiassed consideration of illumination, as distinct from illuminants, and were of value to the lighting industry as a whole. The method might appear somewhat complicated, but he urged people not to be afraid of diagrams, which in the long run might simplify the work of the lighting engineer and enable him to furnish exactly what the authorities desired.

Mr. C. H. WOODWARD (Bournemouth) recalled a time when he disliked the slide-rule, but afterwards became converted to its use. He thought that experience might be similar in regard to the methods now presented. There was just one point he might mention—the methods seemed to assume definite and regular spacing of lamps. Yet most irregular and complex conditions might prevail when the positions of lamps were in a state of alteration. He rather wondered how the diagrams could be obtained or applied in such circumstances.

Mr. C. C. PATERSON remarked that these diagrams only appeared complex because they were unfamiliar. In reality, by their use we might ultimately attain greater simplicity. This development rather illustrated progress in connection with the Standard Specification for Street Lighting, which they all recognized was at present incomplete, and must develop gradually. It was, however, gratifying to those who had devoted so much time and effort to its preparation to see that it was being more and more appreciated and used.

Mr. H. S. ALLPRESS said that he had frequently used similar methods, which were of great aid to manufacturers in enabling them to present their data to public lighting engineers. The iso-lux diagram was the more simple of the two, and the result of moving posts could be readily seen by this method. The speaker also referred to the method of measuring angles in the case of iso-candle diagrams, and the influence of any uncertainty in regard to the exact position of the light-source.

Dr. J. S. G. THOMAS thought that the iso-candle diagram was difficult to understand, and did not lend itself well to the determination of average illumination. He also questioned the desirability of measuring illumination on a horizontal basis.

Mr. R. WATSON (Doncaster), in a written contribution, congratulated the authors of the papers, commending especially the manner in which comparisons between the two illuminants had been avoided. He thought that statements of efficiency in terms of total lumens per unit of energy, without reference to the direction of projection of the light-flux, were misleading. He approved the specifying of illumination in foot-candles achieved on the road-surface.

Mr. G. H. WILSON, in reply, remarked that new methods enabled one to learn more of the aims of street lighting. Iso-lux and iso-candle curves had both advantages. The former was admittedly the most ready method of portraying the illumination of a street-surface. Mr. F. C. SMITH pointed out that in the appendices to his paper both the lower mean hemispherical candle-power and the total lumens had been given; the candle-power in any direction could be obtained from the iso-candle curves. He urged all makers of lamps not to state candle-power without definition, and to include polar curves in their catalogues.

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machines, addressographs, and other pieces of office apparatus can be treated in the same way. The booklet before us also illustrates the application of "typerlites" to bank counters and in rooms containing filing cabinets. Other specialities include the "auction" and "contract" adjustable stand-lamps, which are specially suitable for the lighting of bridge tables.

## Searchlights for Display

In a recent issue we recorded the very large purchase by the London Electric Firm of searchlights from the British Government. Some curiosity might be felt regarding the uses to which such searchlights are put. Actually they are in constant demand for display purposes. We understand that the London Electric Firm has executed large orders from Blackpool. Others have gone to Shrewsbury, Rothesay, and other resorts, as well as to picture-dromes and railways.

The London Electric Firm, it may be added, has recently doubled the size of its Croydon works, after having previously made the largest searchlights in the world—so large that it was necessary to erect them outside the factory. In the new works, which are all on one floor, the height of the ceiling has been approximately doubled, and this not only assists production but renders possible demonstrations of all kinds.

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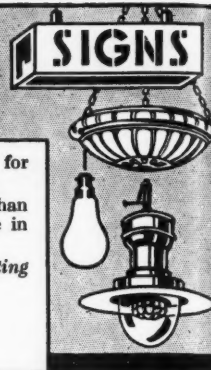
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The next lecture of the Society will be held in the meeting room at the Y.M.C.A., Fargate, Sheffield, on November 7th, at 7-30 p.m., when Professor W. E. S. Turner will lecture on "Glass in the Service of Illumination."

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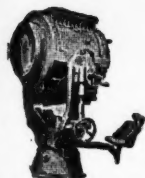
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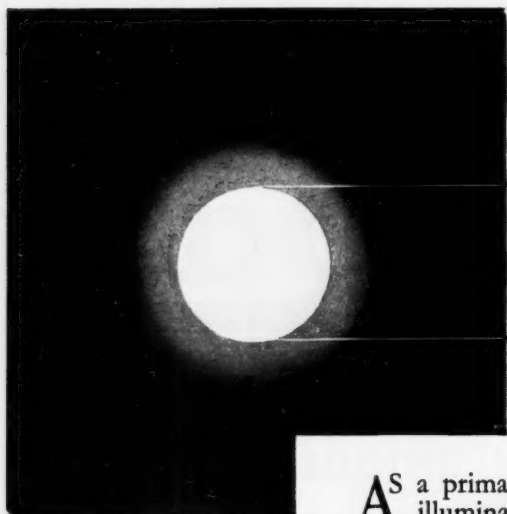
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## The Extensions of the E.L.M.A. Lighting Service Bureau New Address, 2, Savoy Hill

BY taking over part of the premises formerly occupied by the B.B.C., the Lighting Service Bureau has increased its floor space by some 50 per cent., and now incorporates a more spacious entrance and a new general demonstration room. Members of the Illuminating Engineering Society, which held its opening meeting at the Bureau on October 11th, were much interested in the display of novel and attractive demonstrations, a description of which follows:—

### RECEPTION ROOM.

The entrance hall is small and modern in decoration, including in its furnishing a luminous electric clock, and some very modern lighting fittings, but the visitor is encouraged to make immediately for the demonstration rooms.

### NEW DEMONSTRATION ROOM.

This large room contains a number of practical lighting demonstrations (described later) built into



FIG. 1.—A general view of the new Demonstration Room, showing the island structure.

a distinctly modern structure, and in the conception there is evidence of the able design of the Bureau architect.

General lighting is provided by a totally indirect trough surmounting the central demonstration block, and a pleasing effect is obtained from the novel ceiling design so illuminated.

This room is divisible into the following six main schemes:—

1. An island structure carrying seven built-in demonstration cases dealing with lighting principles.
2. A structure housing a demonstration colour window and the E.L.M.A. model street.
3. A recess dealing with the principles of industrial lighting.
4. A recess dealing with the commercial lighting principles.
5. A wall devoted to electric lamps.
6. A miniature electric sign demonstration.



FIG. 2.—Commercial Lighting Recess.

### I. ISLAND STRUCTURE.

The following demonstrations are included in the Island Structure:

#### (a) Effect of Coloured Light.

This model shows how the appearance of a coloured picture is entirely transformed when illuminated alternately by red and green light.

#### (b) Which is the Pearl Lamp?

This display emphasizes by direct comparison that the pearl lamp gives an equal amount of light to the clear lamp.

#### (c) Effect of Daylight Lamps.

Here the application of daylight-blue lamps to the illumination of a picture is clearly portrayed, a coloured print being illuminated by ordinary lamps and daylight lamps alternately.

#### (d) The Effect of Shadows.

Diffused lighting and directional lighting alternately thrown on to moulded subjects and modelling in this demonstration emphasizes the importance of correctly directed light rays.

#### (e) The Effect of Reflected Glare.

In this demonstration a book with highly glazed paper is arranged to reflect an annoying image which makes reading uncomfortable. By pressing a button, the angle at



FIG. 3.—Industrial Lighting Recess.

which the light-rays direct the book is altered and comfortable reading results.

(f) *Importance of Lamp Quality.*

Similar in design to the "Which is the Pearl Lamp?" cabinet, this cabinet shows in a striking manner the typical difference in light output between Association lamps and "cheap" lamps.

(g) *Speed of Discrimination.*

In this demonstration the illumination flashes from 2-80 foot-candles, and effectively demonstrates the much greater visibility of the test objects and small print, the effect being particularly noticeable on a page from a railway timetable.

Adjacent to the entrance doorway a demonstration, entitled "Glareless Light Preserves the Sight," shows alternately a glaring clear lamp and a totally enclosed diffusing unit in the same position, demonstrating the greater eye comfort secured with modern lighting fittings.

## 2. SPECIAL SHOP WINDOW.

The shop window is illuminated by colour-lighting arrangements operated from a motor-driven flasher giving a continuously changing effect. The fascia is equipped with the most modern type of luminous fascia sign.

## 3. INDUSTRIAL LIGHTING RECESS.

The following demonstrations showing the principles of good industrial lighting are incorporated in this section:—

(a) *Reading under Vibratory Conditions.*

In this demonstration two sheets from a newspaper are displayed in identical compartments, the one being on a still platform and the other capable of being vibrated to simulate reading in a moving public vehicle. The light in each compartment can be varied by rheostats from the low level of a half foot-candle up to 40 foot-candles, and it is found when comparing the vibrating object with the still object for equal ease of seeing that a very much higher illumination value is required for the former.

(b) *Light as a Magnifier of Fine Detail.*

In this cabinet many intricate objects are displayed and arrangements made for varying the illumination from a low level through a variety of stages up to a very high level. Individual cards describing the processes involved in each specimen impresses the necessity for adequate illumination.

(c) *Daylight Lamps in Industry.*

Two cabinets are provided showing various industrial applications with daylight lamps, how, for instance, a scorched collar can be identified in a laundry very much better with daylight-blue lamps than with ordinary lamps. The cabinets also indicate how the grading and sorting of various commodities is assisted by the use of artificial daylight.

(d) *Avoidance of Specular Reflections.*

Two cabinets controlled by outside handles demonstrate (1) how by altering the plane of the work, annoying specular reflection can be obviated and the object seen clearly, and (2) how by replacing the direct lighting with entirely diffused lighting, very polished objects can be inspected accurately and in comfort.

The industrial recess also provides accommodation for the miniature factory model, in which the illumination is arranged to switch from poor to correct industrial lighting automatically.

## 4. COMMERCIAL LIGHTING RECESS.

This section incorporates the following demonstrations:—

(a) *Mirror lighting demonstration in which three mirrors are arranged on the normal fitting-room principle, the lighting being specially designed for the purpose. In addition, the display enables the following four striking changes to be made in the lighting:—*

Illumination from ordinary lamps.

Illumination from flame-sprayed lamps.

Illumination from daylight-blue lamps.

Illumination from green-sprayed lamps.

(b) *Luminous Doorway.*

A luminous doorway is incorporated as a practical suggestion to shopkeepers.

(c) *Daylight Lamps in Commerce.*

In this cabinet a variety of goods are displayed showing the application of daylight lamps in shops selling goods which are to be used out of doors. Here again arrangements are made for switching from ordinary lamps to daylight-blue lamps.

This commercial section also provides accommodation for the miniature shop premises.

## 5. LAMP DISPLAYS.

The following three lamp displays are built into one wall of the room:—

(a) *A lamp cabinet showing the ordinary range of electric lamps and the hours burning for one unit.*

(b) *An interesting historic display of early types of incandescent electric lamps representing the Foggo collection kindly presented to the Bureau by Messrs. H. A. Lingard and J. Y. Fletcher.*

(c) *A display showing a 5-kilowatt lighthouse lamp in contrast with a number of extremely small medical lamps, indicating the extremes of the ranges of lamps produced by Association manufacturers.*

## E.L.M.A.'s Twenty-sixth Design Course

The first lecture of the twenty-sixth illumination Design Course of the E.L.M.A. Lighting Service Bureau was given on Monday evening, October 10th, to an audience of 150.

After the opening remarks by H. A. Lingard, Esq., Chairman of the E.L.M.A. Council, Mr. W. J. Jones, manager of the Bureau, gave an address on "Post-war Progress in Electric Lighting." This was in part a review of past achievement, but also a call to greater effort in developing the lighting load. By means of charts and demonstrations Mr. Jones showed how, since the end of the war, the sales of electricity for lighting purposes had shown a very satisfactory increase in the domestic and commercial fields, though the lighting of factories in this country was still in a very undeveloped state.

The speaker offered the services of the Bureau to all those who were concerned with lighting development, illustrating the efforts that were being made towards the collection and classification of data which could be used as sales arguments for better lighting.

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